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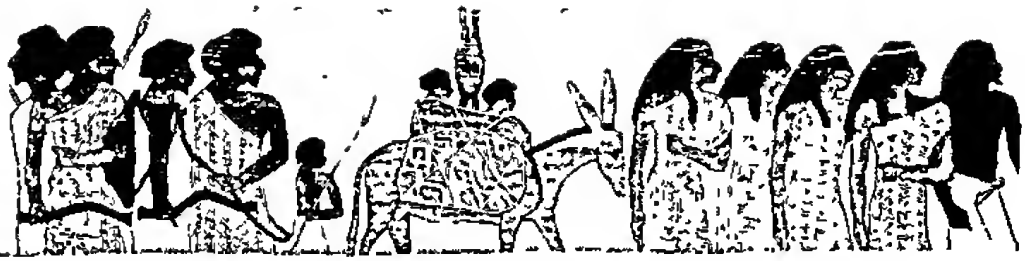
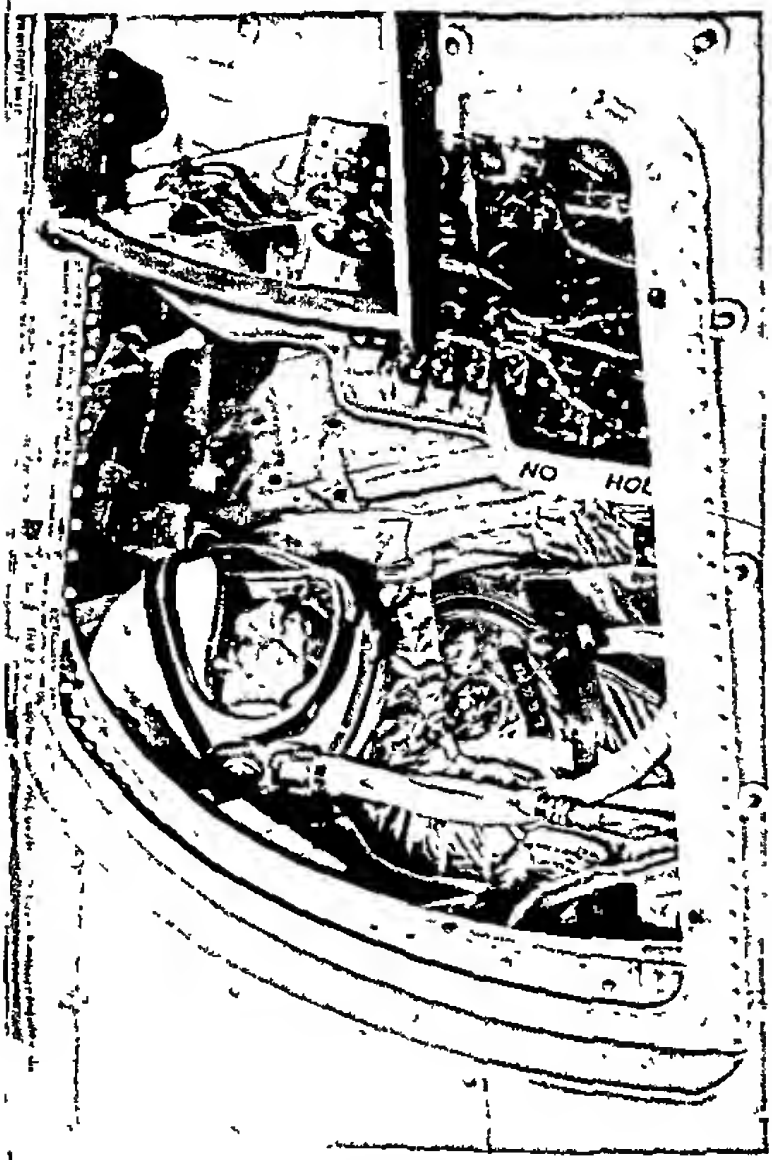


YOUNG PEOPLE'S SCIENCE ENCYCLOPEDIA



PHYSICS • CHEMISTRY • BIOLOGY • ASTRONOMY • GEOLOG
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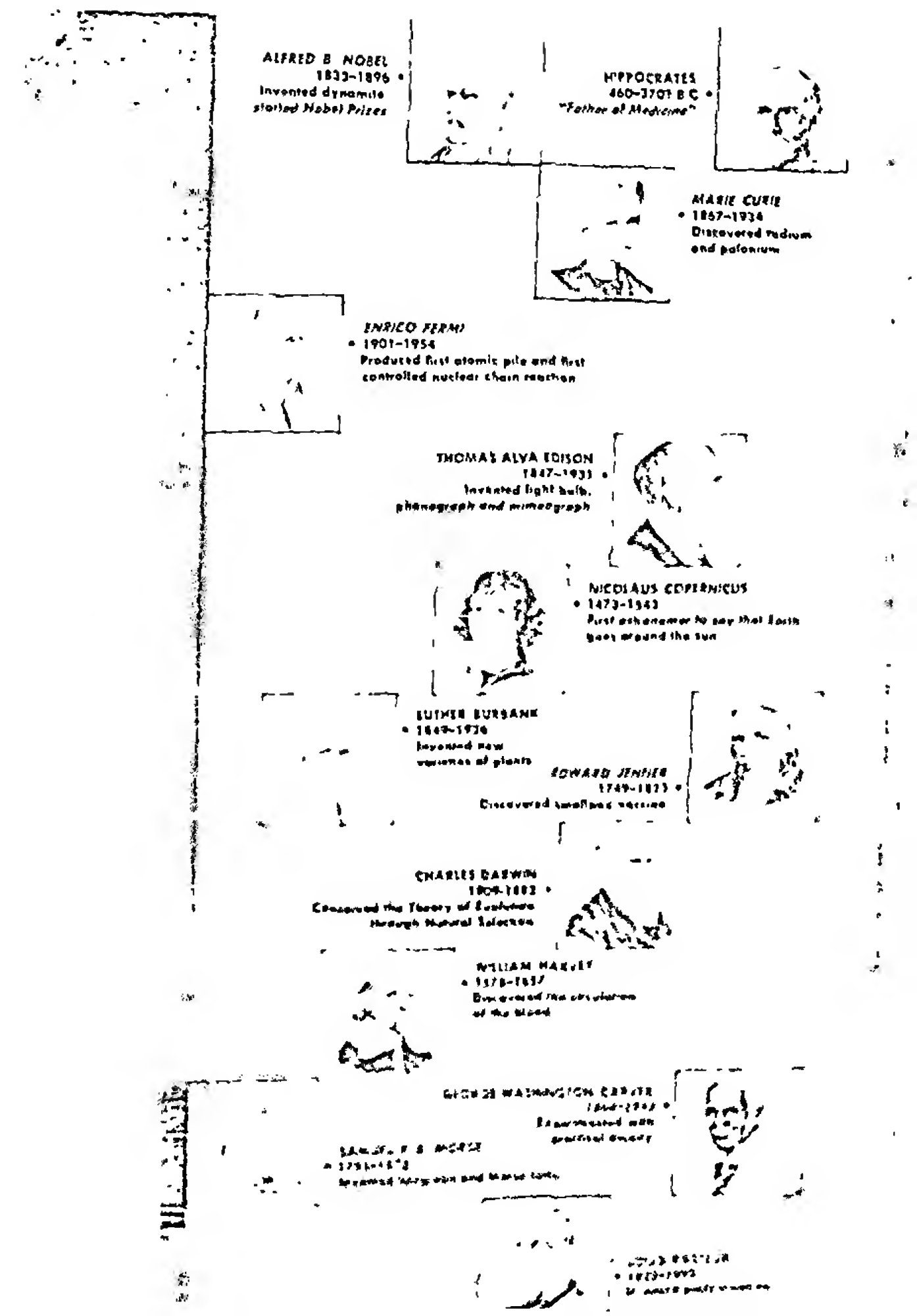
ALFRED B NOBEL
1833–1896
Invented dynamite
started Nobel Prizes
HIPPOCRATES
460–370? B C
"Father of Medicine"
MARIE CURIE
1867–1934
Discovered radium
and polonium
ENRICO FERMI
1901–1954
Produced first atomic pile and first
controlled nuclear chain reaction
THOMAS ALVA EDISON
1847–1931
Invented light bulb,
phonograph and mimeograph
NICOLAUS COPERNICUS
1473–1543
First astronomer to say that Earth
goes around the sun
LUTHER BURBANK
1849–1926
Invented new
varieties of plants
EDWARD JENNER
1749–1823
Discovered smallpox vaccine
CHARLES DARWIN
1809–1882
Conceived the Theory of Evolution
through Natural Selection
WILLIAM HARVEY
1578–1657
Discovered the circulation
of the blood
GEORGE WASHINGTON CARVER
1864–1943
Experimented with
practical botany

GALILEO GALILEI
1564–1642 •
Discovered law of pendulum motion

CAROLUS LINNAEUS
• 1707–1778
Classified the plant and animal kingdoms

SIGMUND FREUD
• 1856–1939
Started psychoanalysis

GREGOR JOHANN MENDEL
1822–1884 •
Discovered principles of heredity

BARON ERNEST RUTHERFORD
1871–1937 •
Contributed to knowledge of radioactivity and atomic structure

GUGLIELMO MARCONI
• 1874–1937
Invented the wireless telegraph

LOUIS AGASSIZ
• 1807–1873
Investigated glacial motion and marine life

MICHAEL FARADAY
1791–1867 •
Discovered electromagnetic induction

SIR ISAAC NEWTON
• 1642–1727
Discovered laws of light, gravity, motion and color

ALBERT EINSTEIN
1879–1955 •
Conceived the Theory of Relativity

WILHELM KONRAD ROENTGEN
• 1845–1923
Discovered X-rays

JOSEPH LISTER
• 1827–1912
Started antiseptic surgery

ALEXANDER GRAHAM BELL
1847–1922 •
invented the telephone

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Edited by the Staff of
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VOLUME 2

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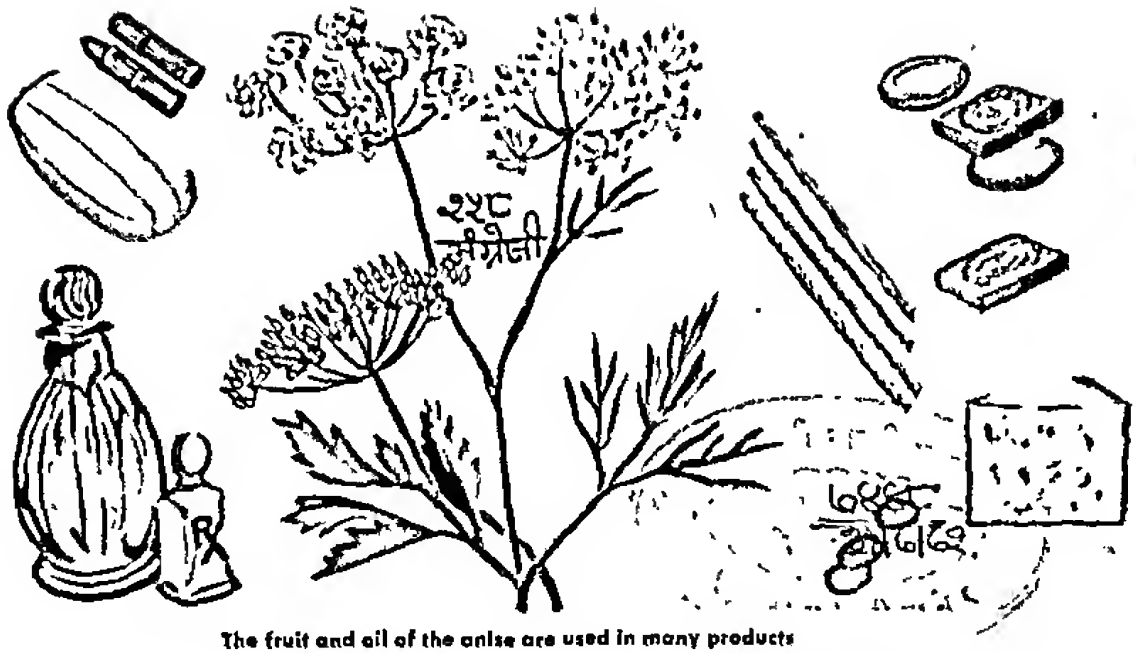


The fruit and oil of the anise are used in many products

Anise (ANN-iss) Anise is a small herb with seeds that have a licorice taste. It is an annual plant belonging to the PARSLEY family. It grows to be two feet high. The small flowers may be yellow or white. The small brown fruit is coated with stubby hairs.

Anise is native to the Mediterranean region but is also grown in many areas of Europe, Asia and South America One variety, the *star* or *Chinese anise*, is a small evergreen grown less widely, mainly in the Far East

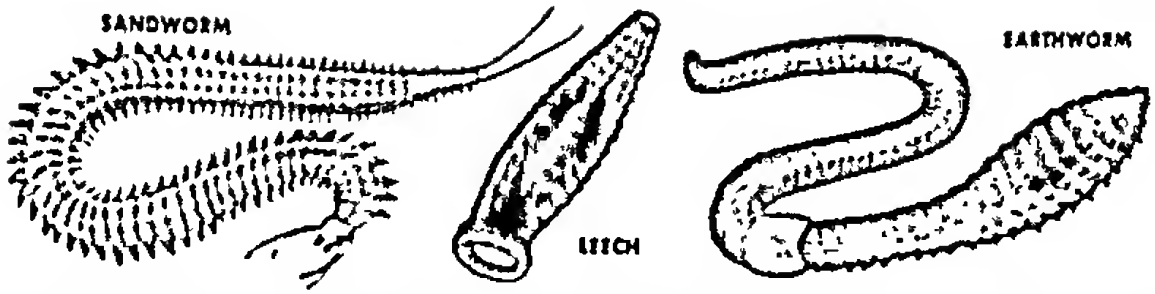
The essential oil (*anethole*) makes up 85% of the seed This is distilled out and used in cosmetics and medicinal preparations. *Anisette* is a liqueur made from this herb. H J. C.

Annealing Annealing is a process of heating and cooling, or of cooling alone, which makes metals and glass harder, stronger and less brittle than they would otherwise be. Annealing helps to prevent internal STRESS which might later cause damage to the material.

SEE: STEEL

Annelida (uh-NEL-luh-duh) The annelids are a large group of worms which have rings around their bodies, dividing them into *segments*. They are long, slender, soft-bodied animals, which move by creeping. They live in the ocean, in fresh water, or in moist ground. The EARTHWORM, the sandworm, and the LEECH belong to the phylum *Annelida*.

In many ways, annelids are organized like freight trains. A freight train is really a long line of connected railroad cars, pulled by an engine. Each car is a separate part of the train, carrying its own load. But the cars are useless, as freight cars, unless they are connected to one another and to the engine. The engine is useless, unless it has freight cars to pull. The engine and the cars must work together to carry freight. Annelids, like trains are made up of separate sections. Each ring is a separate part of the worm. These sections are divided by a thin wall or partition, just as the cars of the train are closed off from one another, by two end walls. Annelids have a front and a rear end, just as the train has an engine and a caboose. The head moves first and the rest of the body follows. When a train goes around a curve, the cars are able to turn separately. It is an advantage for a worm to have a body built in sections, because each section can move separately and can perform special duties.



The sandworm, leech and earthworm are the most common annelids. Each parapodium on the sandworm serves as both a respiratory and a locomotive structure. The leech uses both of its suckers for locomotion and the mouth attaches to a host for feeding. The earthworm has bristles, or setae, on each segment. The bottom ones are for locomotion and the others are sense organs to the environment

The Latin word *annellus*, means ring. Annelids are members of a large phylum of ringed or segmented worms, which differ in size, location and feeding habits. Included are both tiny worms, used as food for pet fish, as well as giant earthworms, which live in the tropics and grow to eleven feet in length. While the tube and sandworms live in burrows along the ocean, the earthworms live in moist soils all over the world. Burrowing worms swallow great amounts of sand and soil, from which they extract decaying plant and animal matter. Parasitic worms, like the leeches, feed on blood by attaching themselves to the bodies of fish and other vertebrates. With their suckers, they are able to extract three times their own weight in blood, which they store as food for several months.

The body of the annelid is simple in structure. There are two tubes, a small, hollow, digestive tube, inserted into a large outer tube. The tubes are joined at the mouth on the first segment and at the anus on the last segment. Between the tubes, there is a space called the body cavity or *coelom*, which is filled with a fluid. The coelom is divided into compartments by the thin partitions between the rings or segments. Thus the fluid is confined within the segment. Contained in the thick outer tube, are two types of muscles. Circular muscles, which go around the body, contract to make the body *longer and thinner. Longitudinal muscles*, which run the length of the body, contract to make it shorter and thicker. The outer tube is covered with a *cuticle* which prevents the body from drying and allows for exchange of gases in respiration.

Among worms, annelids are unique, since ·w have paired feet for locomotion. Ex- ing from the sides of each segment, are fleshy lobes, called *parapodia*, or tufts of bristles, called *setae*, or both. The feet beat like paddles to propel the worm; the bristles anchor the body to the ground.

Simple transportation systems are present. The nervous and circulatory systems run the length of the body. The nervous system consists of a dorsal brain and ventral nerve cord. The circulatory system is a closed circuit of branching blood vessels which propel the red blood by wave-like contractions (*peristalsis*) and prevent back-flow by a system of valves. Excretory funnels, the *nephridia*, in almost each segment, remove wastes from the blood and coelomic fluid. Reproductive organs are found in several anterior segments. Some species of annelids have separate males and females; others are hermaphroditic—both male and female in one animal. Some annelid eggs hatch into larva before they develop into adults.

Annelids are really advanced worms. Due to the presence of segments and appendages, these animals have achieved great control of body movements. E. P. L.

SEE ALSO: ANIMAL; ANIMALS, CLASSIFICATION OF; NEMATHELMINTHES; PLATYHELMINTHES

Annual Annual is the name given to all plants that complete their life (growth cycle) within a single growing season. During one season, usually *spring and summer*, they grow from a seed into a full-sized plant, bloom, bear seeds and die.

Annuals are usually small with soft stems and branches. Their short life span prevents them from laying down any woody tissue. Most plants in a vegetable garden and many flowering garden plants are annuals.

In cultivated plants, the seeds are planted

in the spring. In wild plants, the seed remains dormant—"asleep"—in the soil during the winter. They sprout and begin to grow when spring weather comes. Some annuals germinate in the fall, live through the winter in a vegetative condition, and bear seeds the following spring. Others may complete their growth cycle in one growing season in certain climates but require two seasons when growing in other climates. "Winter wheat," grown in the Central Plains of the United States, is planted in the fall, and sprouts and remains in a vegetative condition under winter snows. It bears its seed in spring and is harvested in early summer. In climates having little snow, WHEAT is a true annual and is sown in the spring.

The length of the life cycle of annuals varies Generally it is from two to three months. In desert regions, an annual may complete its cycle within a period of two to four weeks. I. H. S.

SEE ALSO: PLANT

Annual rings Annual rings are the dark and light colored rings that can be seen when a tree is cut through the trunk. The age of the tree can be told by the rings. A light ring grows each spring and a dark one grows each summer and fall. Too little sunlight and moisture, injury, or age of the tree sometimes causes the annual rings to vary in width.

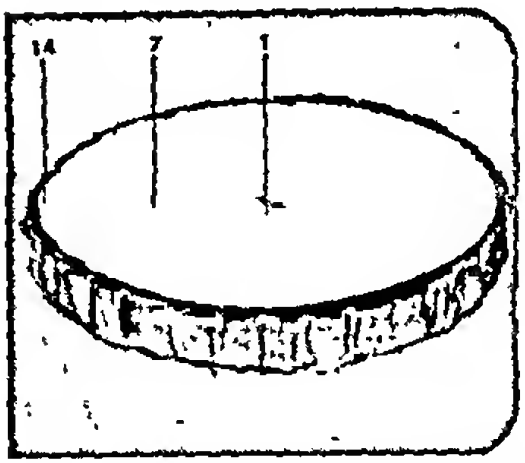
Annual rings are formed by living cells just inside the bark of the tree. These cells serve as a transportation system from the roots to all parts of the plant. Spring cells are usually larger than those grown in summer, and lighter in appearance. I. H. S.

SEE ALSO: CAMBIUM, PHLOEM, TREE, VASCULAR TISSUES, XYLEM

Anode The anode is the positive ELECTRODE by which an electric current enters a conductor. The conductor may be a liquid, a gas or a solid. The anode may be a terminal post as in a storage battery, a prong as in a radio or television tube, or a plate of impure copper as in the electrolytic refining of copper.

✳ THINGS TO DO

HOW OLD IS A TREE?



1. Secure a cross-section of a tree which has been cut down in the neighborhood.
2. Sand the surface until it is very smooth. Brush on clear shellac or varnish to bring out the "grain" in the wood.
3. Starting from the center (the first year's growth) count a light and dark band as one year. Notice how some bands are wider than others.
4. What would cause the wider bands? How old was the tree when you were born, when you started to school?

The anode may be the positively charged copper strip of a wet cell of the plus-electrode of a television picture tube.

The anode is always positively charged, and the CATHODE is negatively charged. This is why the anode attracts the negatively charged ions or anions. It is at the anode that the anions give up their electrons and become oxidized. I. K. F.

SEE ALSO: ELECTROLYSIS, IONIZATION

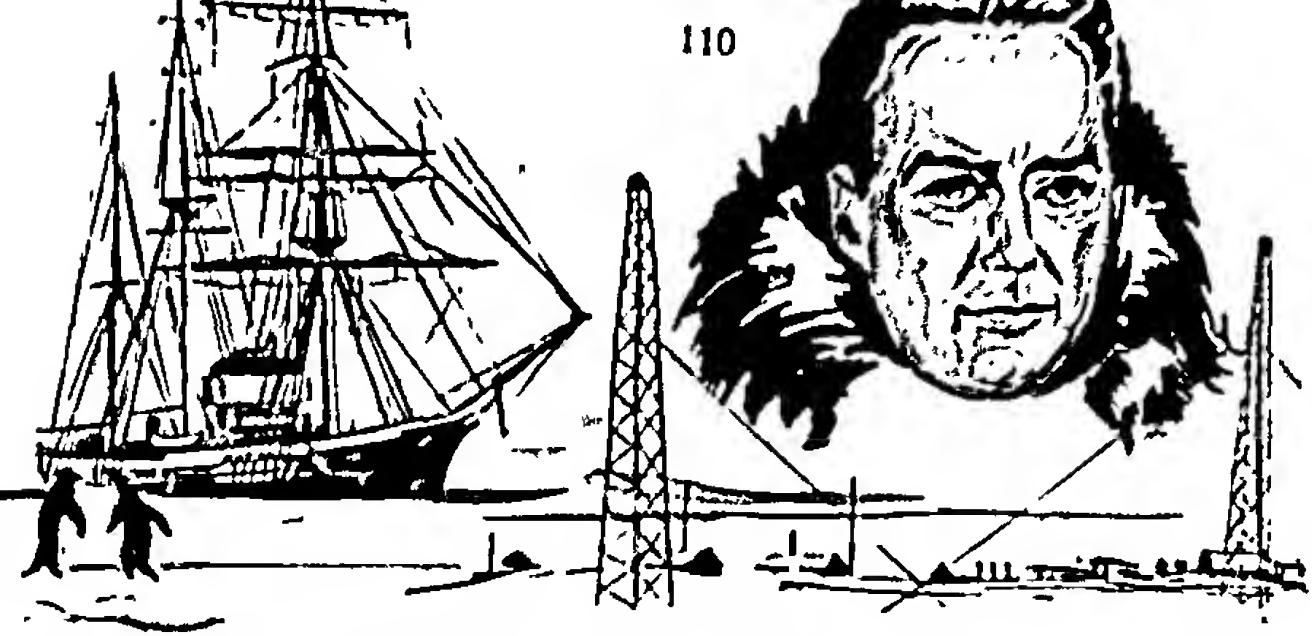
Anopheles see Malaria, Mosquito

Antacid An antacid is a chemical substance which lessens the amount of acid in the stomach either by neutralizing or by absorbing it.

SEE: ACIDS AND BASES, DIGESTIVE SYSTEM

Antagonist see Muscle system

Antarctic current see Currents, ocean



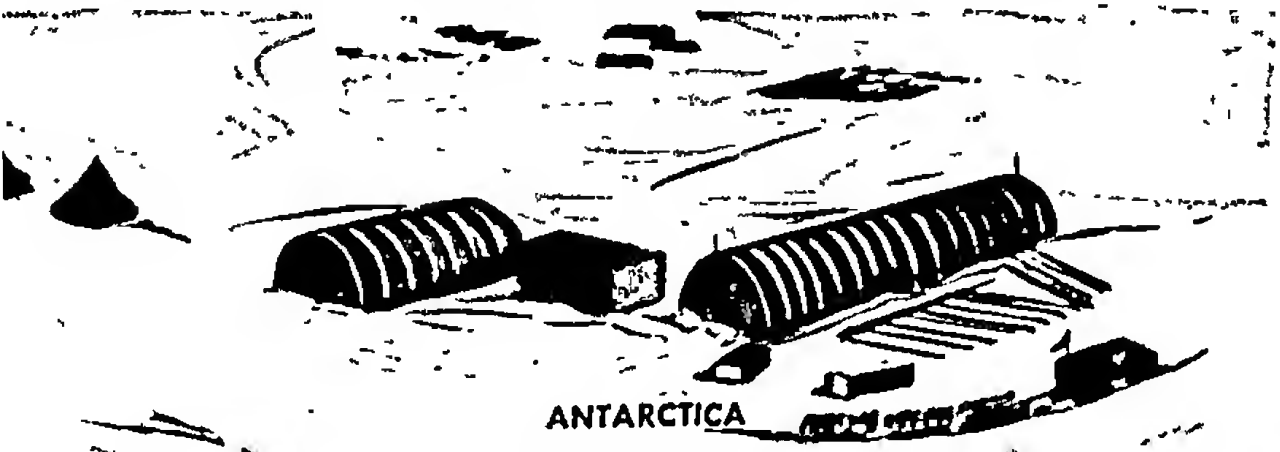
Little America, the base established by Admiral Richard E. Byrd in 1928, was revisited by him in the sailing ship *Bear of Oakland* in 1939

Antarctica (ant-ARK-tick-uh) Antarctica is the name of the continent on the southernmost part of the earth. It is a land of ice and snow surrounded by the stormiest seas in the world. The temperature is the coldest on earth. Antarctica is so large and desolate that not all of it has yet been explored.

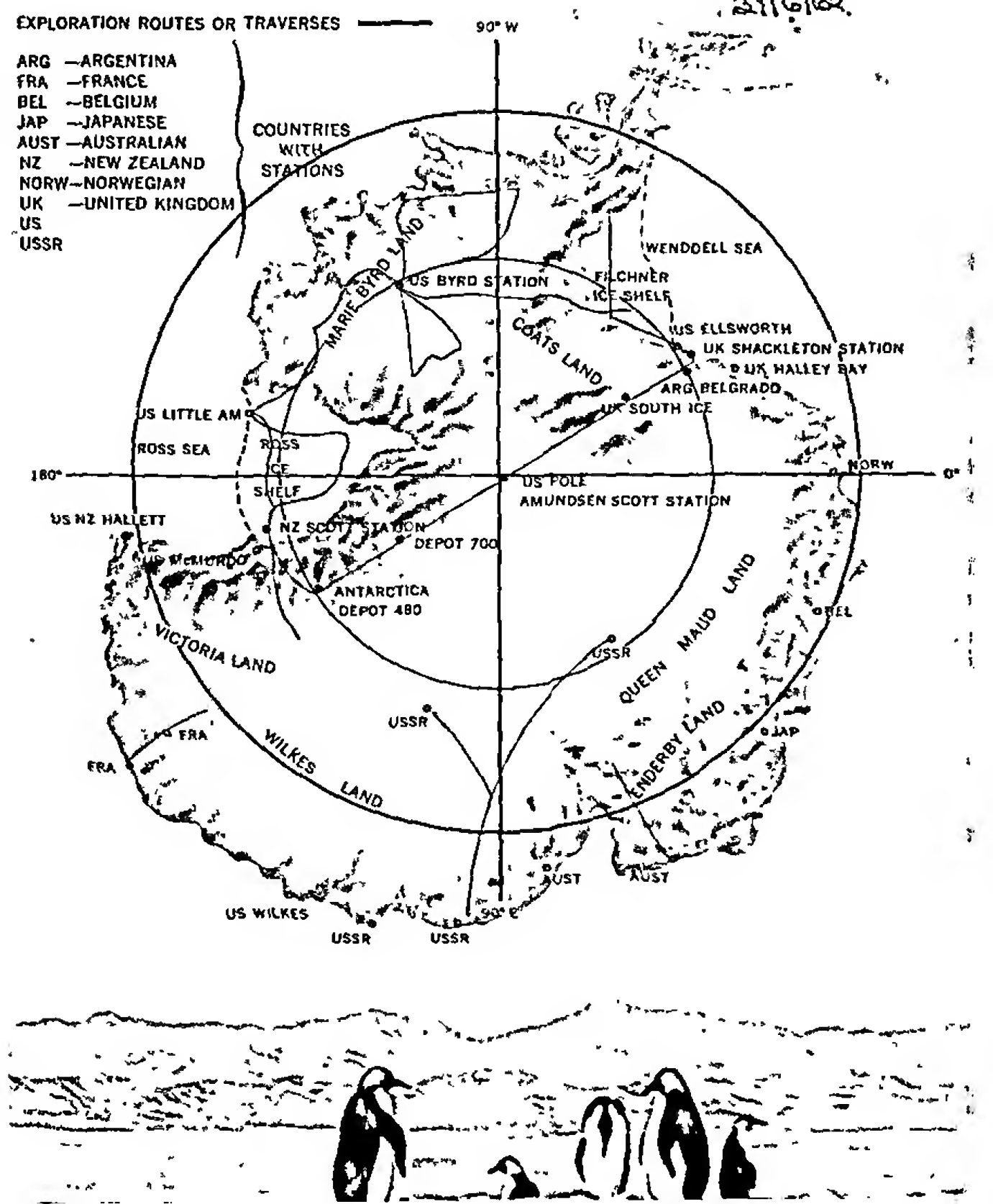
Before 1900, people knew little about Antarctica except the shape of some of its coastline. Captain James Cook, a British explorer, first reached the area about 1774. Some time later, a Russian named Bellingshausen discovered two islands and the sea which bears his name. The long, finger-like PENINSULA which extends westward from Antarctica was named after the American explorer Nathaniel Palmer, who discovered it, though he had no idea that Antarctica was a continent. In 1823, James Weddell found a sea north of Palmer Peninsula. It is now named for him. It wasn't until 1840 that Charles Wilkes identified the area as a continent. He had followed the coast for about one thousand miles. A year later James Clark Ross of Britain discovered the famous Ross Ice Shelf. From then until the turn of the century, new knowledge concerning Antarctica was very slight.

In the twentieth century extensive expeditions have been undertaken to learn more about this vast continent. Despite these attempts, over a million square miles are yet to be explored. Ernest Shackleton of Great Britain attempted to reach the South Pole in 1908–1909 but failed. On December 14, 1911, ROALD AMUNDSEN was the first man to reach the South Pole. A month later on January 18, Robert Scott, an Englishman, arrived there. Not until 1928 did a man fly over the Pole in an airplane. Hubert Wilkins did it. In 1929 Admiral RICHARD E. BYRD established, off the Bay of Whales on the Ross Ice Shelf, an outpost called Little

Operation Deep Freeze is a government project for establishing military bases and a power station in Antarctica



ANTARCTICA
I.G.Y. TRAVERSES, BASES



Courtesy Society For Visual Education, Inc.

The sun does not shine for six months of the year at the south pole

America. On November 29 of that year he, too, flew over the Pole. Byrd has since led several expeditions to Antarctica—1934-35, 1940, and 1946-47. In 1935 he was surprised to learn that part of the ice shelf had dropped off into the ocean. A group of seven men from the U.S. Navy landed at the Pole by plane in 1956 and installed radar reflectors. Continued exploration is financed and encouraged by the National Science Foundation and the United States Government's Operation Deep Freeze for the purpose of establishing air bases and building an atomic power station at McMurdoo Sound.

One hundred million years ago Antarctica was covered with vegetation and had a climate similar to that of California. The extensive amounts of COAL found underground, as well as the existence of fossilized animals, prove this fact. Today, this vast ice land is at least thirty-five degrees colder than the North Pole. Some evidence recently uncovered shows that parts of the continent are growing warmer and temperatures above freezing have been recorded. However, the temperature in winter may be as low as eighty below zero along the coast and below one hundred degrees below zero in the interior. The strong, driving winds, of fifty to one hundred fifty miles an hour are often filled with snow and cause blinding blizzards

While the northern hemisphere enjoys its summer, Antarctica is having its cold, dark winter because the sun does not shine for six months of the year at the South Pole. Though there is sunshine in the summer months, the temperature hovers around zero. Surprisingly enough the snowfall in Antarctica is light. At the Pole less than ten inches fall a year, and around the coastal areas the fall may still be only about twenty-five inches. Since the inland temperatures are never above freezing, the snow hardly melts, and therefore more accumulates each year. Rain is completely unknown.

Antarctica is somewhat circular in shape. Deep bays cut into its irregular coastline, and on the western side the lengthy Palmer Peninsula juts far out into the Weddell Sea. Actually the whole continent seems to be an island surrounded by the turbulent Antarctic Ocean, which is composed of the southernmost parts of the Indian, Atlantic, and Pacific oceans.

Antarctica, the fifth largest continent in the world, is 5,300,000 square miles in area. It is two-thirds as large as North America. The surface of the area is covered by an ice cap, averaging several thousand feet in thickness. Its surface is around 6,000 feet above sea level, but at the Pole its altitude is 10,500 feet. There are mountains underneath the ice, and peaks rise through the ice in some parts, particularly along the east and west coasts. Only one mountain, Mount Erebus, is an active volcano. The interior of Antarctica is an unbroken plateau of ice. It is believed that it would be a solid land mass with many mountains if the ice melted. From time to time the masses of ice and snow slide down, and this movement pushes the border into warmer regions. The ice sometimes melts a little and the ocean tears off huge chunks, known as floes and icebergs, which are very dangerous to ships. The ice shelves along the coasts are huge masses of ice that extend far out into the water. Some of these rise thirty to one hundred feet above the water. The Ross Ice Shelf, four hundred miles long, is the largest.

Little plant life exists in Antarctica. Only a few scattered areas have mosses and lichens. DIATOMS, so tiny they can be seen only under a microscope, are food for small sea animals which are eaten by the fish.

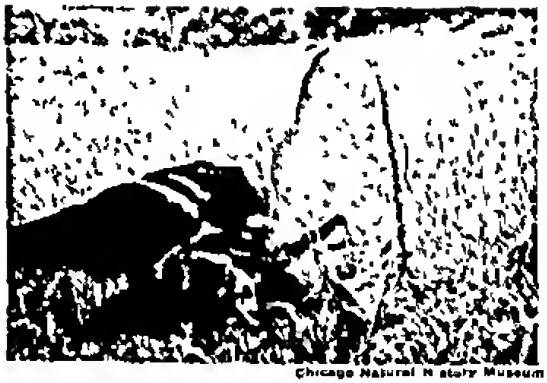
There are no living creatures on the land except some tiny insects in summer and a few birds. These include the PENGUIN, ALBATROSS, petrel, and some varieties of gulls.

Antarctica, through the Twelve-Nation Treaty signed in Washington, D.C. on December 1, 1959, is to be a scientific preserve. The main objectives of the treaty are to assure the use of Antarctica for peaceful and scientific purposes, and to continue expeditions started during the INTERNATIONAL GEOPHYSICAL YEAR OF 1957-1958.

D. E. Z.

SEE ALSO: POLES, NORTH AND SOUTH

Antares see Scorpius



Anteater

Anteater There are several kinds of anteaters. Their main food is termites and other small insects. They have long, tube-like noses, like a pig's. A long tongue pops out of the snout to gather in termites. They also have long, sharp claws to help them uncover termite nests and fight their enemies.

Anteaters are mammals and the babies stay close by the mothers until they are old enough to live in the dense forest by themselves. Some kinds of anteaters live on the ground and have great strength as well as sharp claws to help them survive. Other smaller ones live in trees and have *prehensile* tails, like a monkey's, so that they can swing from branch to branch looking for food. Sticky saliva on the tongue captures the insects after the anteater has broken into a nest. All true anteaters are from Central and South America. M. E. C.

SEE ALSO: AARDVARK

Antelope Antelopes are four-legged hairy mammals. They have split hoofs and horns. Many of them look like deer, but they are more closely related to goats and oxen. They vary greatly in size. Some are as small as jack rabbits (about 10 inches high) while others may stand six feet tall.

Antelopes' horns are hollow and do not branch out like those of deer These animals grow only one pair of horns in a lifetime The females of most small antelopes have no horns. There are also some large female antelopes which are hornless.

Antelopes are ruminant animals This means they have a four-chambered stomach All such animals swallow their food without chewing it. Later the food is brought up in small masses to the mouth again and is chewed. The phrase "chewing its cud" refers to the antelope as well as to cattle

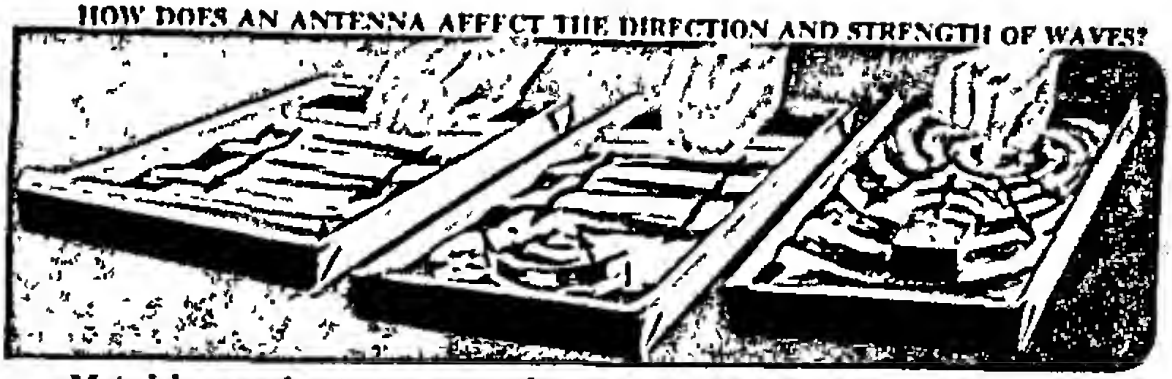
There are no true antelopes native to North America Most of them are found in Africa In the western section of North America there is a group of animals who have been named pronghorn antelopes Though they resemble antelopes, they belong to a different family. Antelopes live in a variety of places. They usually travel in herds or groups There are many different types of antelopes. Some of the best known varieties include the lesser gnu, the dik-dik, the eland, the impala, the blackbuck, the duikerbok, and the African lechive. Man uses the flesh and the skin of antelopes as he does that of the deer. G. A. D.

SEE ALSO: DEER FAMILY, UNGULATA

Dik-dik antelope of Abyssinia

Blackbuck antelope of India

✳ THINGS TO DO



Materials: pan of water, paper towels, coffee can rim, differently shaped objects

1. **Set up pan of water with paper towels at one end to absorb waves so that they won't bounce back.**
2. **Start small ripples moving with a ruler or stick, until regular waves are made.**
3. **Use a "dish" type antenna bent from the rim of a coffee can. The waves will be collected and reflected to a point where they are concentrated, bigger and easier to notice.**
4. **Try other shapes—plain, straight, curved the other way—to see which reflects and concentrates waves best.**

Antenna (animal) *see Arthropoda*

Antenna (electronic) An antenna is the portion of a radio system that sends out electrical signals into space or receives these signals from space. The most familiar types of antennas are those found in radio, television, and radar transmitters and receivers.

Antennas differ widely in their size, shape, and construction according to the job each one is designed to do. Antennas for very low frequencies may be as long as a mile or as high as one-sixth of a mile, while those for high frequencies may be no larger than a button.

The antenna for a RADIO receiver is the simplest of all. Often it is merely an outside wire suspended between two posts or trees. The antenna for a radio station is usually a tall metal tower or a long wire. One end of the antenna is high in the air while the other is connected to the ground.

A TELEVISION transmitting antenna usu- of several short rods attached positions along a high tower. receiving antennas are of three *the straight dipole, the folded* and the combination straight-folded

complicated and involved antennas, or aerials, have been developed for the radio telescope, navigation aids and military systems. L. K. F.

SEE ALSO: ELECTRICITY, RADAR

Anterior see Animals, classification of

Anthracite coal see Coal

Anthropoid ape see Ape, Evolution of man, Monkey, Primates

Anthropology Anthropology tells about man and how he grew through the ages. It is a long story. It tells about the earliest kinds of people and how they lived. It also tells many facts about animals and how they changed through the years. The science includes the habits of different people living on the earth today. An anthropologist is interested in the art, language, family life, biology, and laws of all people since men first came to earth.

The word *anthropology* comes from two Greek words. *Anthropos* means "man," and *logos* means "ordered knowledge." Therefore, *anthropology* is the ordered knowledge of man. Two main divisions of this knowledge are *cultural anthropology* and *physical anthropology*. According to Ashley Monta-

gue, the noted anthropologist, culture is the man-made part of environment This includes the pots and pans, the laws, art, religion, and philosophy of man Therefore the anthropologist is interested in all forms of social behavior and organized society He studies human nature Until recently, most studies in anthropology had to do with primitive people, but now the scientists in this field are making studies of more advanced people of the earth, such as the Chinese, Germans, English, and Americans

The science of ARCHEOLOGY is used in the study of cultures that no longer exist Archeologists make careful studies of the rocks, soil layers, and the remains of animals and man-made items which are discovered in their searches Through excavations and studies, archeologists have been able to solve many problems of the relationship of cultures which would have remained puzzles forever.

The physical anthropologist makes a study of man's beginning and the changes that have taken place in his body through the ages

Man's progress may be thought of in a series of three main steps Step one includes a study of the Lower Paleolithic or early men who lived during the Stone Age and were the last people to make their living mainly through hunting Step two introduces the first food growers These were the Neolithic people who can be distinguished as different races Many of these races found their home in places now called Europe, Asia and Africa In this "step" was progress in invention and religion, and a higher organization in society In this stage one could trace the origin of the earliest Americans in the New World, the Indian and his civilization The third step in the story of man's progress is the development of the "cradles of civilization" in Asia and the early history of Egypt, Crete, and the beginnings of Europe

Interesting phases of the study of anthropology include the marriage customs, family life, art work, the making of weapons, and types of written expression of the people of any period Problems of laws, morality, and religion are also included in a study of anthropology

SEE ALSO EVOLUTION OF MAN D F Z

Prehistoric men knew the use of fire and tools Some left pictures on cave walls

Facts about the history of man can be obtained by investigating primitive people of today

Physical anthropologists used the Heidelberg skull, found in 1907, to show evolution

Antiaircraft see Missile

Antibiotics One of the newest ways to fight germs is through the use of antibiotics. An antibiotic is a medicine made from substances produced by tiny microscopic plants or animals. The medicine kills germs that are harmful to people.

About 1875, LOUIS PASTEUR and John Tyndall in England noticed that when two different kinds of BACTERIA are together, one kind often kills the other. This situation is called *antibiosis* which means "against life."

Little work that was helpful to man was done on this observation until 1929 when ALEXANDER FLEMING accidentally discovered a substance in a growing mold which killed pathogenic (disease-producing) bacteria. This substance was an antibiotic. He called it PENICILLIN.

Although Fleming reported his discovery, it was not until ten years later that the importance of the substance as a drug was realized. At that time, an English doctor named Howard Florey and a German doctor named Ernst Chain decided to make enough penicillin to test on human beings.

Penicillin had several disadvantages, however. It could be obtained only from a mold, could not be taken by mouth, and was effective against only a few bacteria. So a search for an antibiotic with a wider range of effectiveness which could be taken by mouth was started.

Since that time about 3500 antibiotics have been obtained, but only about 16 have proven to be useful. The rest are either too strong to be used by human beings or they are not strong enough to kill germs. The chart below shows some of the more familiar antibiotics, some of the diseases they are used against, and where they are obtained.

Antibiotic drugs must be taken with caution because sometimes the body will become sensitive to them and react against them. Also, the pathogenic organisms may become immune to the poisonous substance. In this case the drug loses its effectiveness. V. B. L.

SEE ALSO: DRUGS, PHARMACOLOGY

Antibody Whenever harmful germs enter the human body, the body tries to destroy them. This is done either through the white cells of the BLOOD or through the manufacture of a chemical compound known as an *antibody*.

When a person becomes ill from germs that have entered his body, the body immediately summons its defenses. Some antibodies help the white corpuscles destroy germs. Others make germs stick together to prevent their spreading throughout the body. Still others make the *toxins*, or poisons, in the germs harmless. This latter kind of antibody is known as an *antitoxin*. The substances which enter the body and stimulate the production of antibodies are called *antigens*.

When the body has successfully fought off a disease, an IMMUNITY is built up against that disease, sometimes for a lifetime. However, the body is not always successful in destroying disease germs. In order to combat diseases which are often fatal, scientists have developed VACCINES which prevent the contraction of many of these diseases. The first

ANTIBIOTIC AND YEAR INTRODUCED	ORGANISMS WHICH PRODUCE IT	SOME DISEASES IT HELPS CURE	
ACHROMYCIN 1952	Streptomyces species (soil microbes)	Anthrax Pneumonia	Typhus fever Whooping cough
AUREOMYCIN 1948	Streptomyces aureofaciens (a soil microbe)	Diphtheria Pneumonia	Scarlet fever Typhoid fever
CHLOROMYCETIN 1947	Streptomyces venezuelae (a soil microbe)	Dysentery Meningitis	Urinary tract infections
ERYTHROMYCIN 1952	Streptomyces erythreus (a soil microbe)	Carbuncles Pneumonia	Osteomyelitis
PENICILLIN 1928	Penicillium notatum (a mold)	Meningitis Syphilis	Tetanus Tonsilitis
STREPTOMYCIN 1944	3 Streptomyces species (soil microbes)	Tuberculosis Undulant fever	Urinary tract infections
TERRAMYCIN 1950	Streptomyces rimosus (a soil microbe)	Amebic dysentery Diphtheria	Rheumatic fever Typhoid fever

person to experiment with such a vaccine was an English physician named EDWARD JENNER. In 1796 he vaccinated an eight-year-old boy with serum taken from a cowpox sore on a milkmaid who had contracted a mild form of the disease. The boy did not contract cowpox.

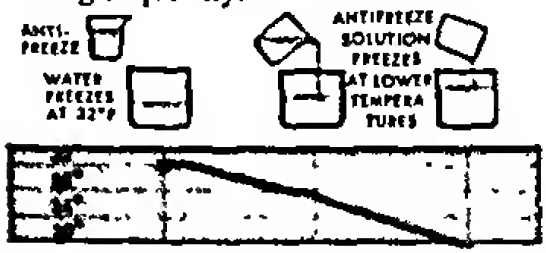
The principle which Dr. Jenner had discovered is that when the vaccine containing a poison enters into the blood stream of a person, the body immediately envelopes the vaccine with antibodies and destroys the poison. These antibodies remain in the blood to establish immunity against future infection

V. B. I.

SEE ALSO: ALLERGY

Anticyclone see High pressure center

Antidote An antidote is a remedy for poisoning. It may remove the POISON, neutralize it, prevent the body from absorbing it, or assist the body in eliminating it quickly.



Antifreeze Antifreeze is any substance which, when added to a liquid, lowers the freezing point of that liquid. It is commonly used in the cooling systems of automobiles, airplanes, tractors, and refrigerators.

Antifreeze is added to the cooling liquid in the radiator of an internal combustion ENGINE. In cold weather it is used alone or with water to prevent the freezing of the cooling system. Also it is used to prevent icing on leading edges of propellers and wings of airplanes.

The most important antifreezes are methanol, ethylene glycol, and ethyl alcohol. Calcium chloride and sodium chloride are used in refrigeration.

Drugs and cosmetics are protected from freezing during storage by means of glycerol and ethyl alcohol. Brand name antifreezes have corrosion inhibitors added. W. J. K.

SEE ALSO: ALCOHOLS

Antigen see Allergy, Antibody

Antihistamine see Allergy

Antiknock see Ethyl

Antimatter Atoms of ordinary matter contain *protons*, which are positively charged; *neutrons*, which are not charged; and *electrons*, which are negatively charged. If atoms could be built of equivalent particles with opposite charges, antimatter would result.

Scientists have shown that antiparticles such as positrons (positive electrons), antineutrons, and antiprotons (negative protons) exist and can be created in the laboratory. Both the particle and its antiparticle have the same mass. When an antiparticle encounters its particle, they destroy each other. This process is called annihilation. In annihilation, the destruction of matter and antimatter causes a large release of energy. According to the Einstein equation, the energy released equals $E = 2\ m\ c^2$. In like manner, to create the pair, particle and antiparticle, requires an amount of energy also equal to $2\ m{\cdot}c^2$ where m is the mass of the particle and antiparticle pair, c is the velocity of light.

In 1956, scientists Yang and Lee (Nobel Prize winners) performed some of the first experiments directing attention toward antimatter. J. H. D.

SEE ALSO: NUCLEAR SCIENCE

Antimony (ANT-ih moh-nee) Antimony is one of the elements known as a *semi-metal* or *metalloid*. It has some of the properties of a metal and some of the properties of a nonmetal. Like most metals, it has a high luster or shine. Unlike most metals, it is brittle and a poor conductor of electricity. It does not rust or tarnish.

Compounds of antimony were known in ancient times when it was used to make eyes more beautiful. During the Middle Ages it was known

Ants Ants are small insects with six legs. Like BEES, they are social insects. They dig tunnels in the ground or in wood where they make their homes and store food. A great many of them share the same home, food, and care of ant eggs and ant larvae. A large group of ants living and working together is called a *colony*.

Most authorities believe that the ants form a very large group in the insect world. They estimate that there are between two and five thousand species in existence. They also find that all these different species are very much alike in their structure and their habits.

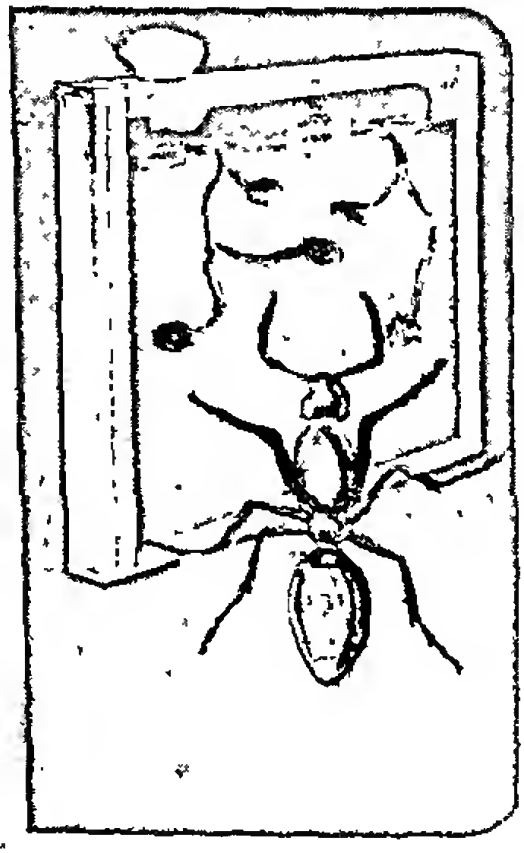
Ants are identified by their two-sectioned abdomen, their bent antennae, their stinger located at the tip of the abdomen (in some ants), and their social organization.

Ants have a more complex social organization than any other animals. Experts in the United States Department of Agriculture report that there may be eight distinct castes—or group levels Not all castes are in the same individual species, though five castes may occur in one species. Each caste has its special tasks. There are not only the large workers and the small workers, but in certain species there is a well-developed caste which does most of the fighting for the entire community. This type is called the *soldier ant*

In a colony of ants there are often thousands of sterile females who are known as the *workers*. They are "ruled" by one or more females known as *queens*. Most ants of both sexes have wings in their early life Females lose their wings soon after swarming and the raising of the brood. Males keep their wings until they have mated with the

✳ THINGS TO DO

CONSTRUCTING AND STOCKING AN ANT COLONY



Materials: two sheets of 12" by 18" glass, two wooden strips 1" by 1" by 12", two strips 16", dark paper

1. **Build the ant home according to the illustration. Drill a hole in the top piece of wood through which food and water may be put. A cotton plug in the hole will keep ants inside. Keep the top piece moveable for stocking the colony. Tape the other edges.**
2. **Locate an ant hill. Dig up one square foot of soil around it. Place the soil and ants on a piece of white cloth. Examine the contents until the queen is located. The workers will not live without the female in the colony. Transfer the colony to the new home. A newspaper funnel may be used to get the ants and soil from the cloth into the narrow structure.**
3. **Cover the glass with dark paper for two weeks to encourage the ants to make tunnels and rooms close to the sides for observation. Ants need honey, sugar water, and wet sponge placed on top of the soil line.**

queen, but they soon lose their wings and their lives after the mating season.

Because the behavior of ants in their community life is so well organized, it has been compared to an ideal nation in which everyone works for the good of all. However, it cannot be assumed that ants have any high degree of intelligence. One writer says that most insects are influenced by light, but he insists that they learn nothing.

Other scientists believe that some ants travel only on paths which have been established by other members of the same group. The sense of smell keeps them on their course. There are certain ants, however, which appear to depend upon sight rather than smell in reaching their destinations.

Ants live in large groups. Each kind, or caste, of ant has its own work to do

A few groups of ants are *carnivorous* and they prey upon other ants and insects for their food. Most ants, however, are vegetarian and eat things like leaves and grass. The *doryline* ants are tropical in their habitat, and they never settle down to live in one area. They forage for food in large swarms.

Ants do curious and interesting things

Ponerine ants feed insects to their young and they are equipped with powerful stingers. One rare type of ant grows fungi for food. These ants are often called "mushroom growers." *Formicine* ants which secrete an acid (called formic acid) as a means of protection do not sting with a stinger.

Courtesy Society For Visual Education, Inc

Winged queen black ant

The "carpenter ants" of North America and Europe are so called because they often nest in wooden timbers of buildings and thereby weaken the structure. Slavery and raiding of other ant colonies goes on among ants of the "carpenter ant" type.

An unusual group of ants known as "honey ants" obtain sweet juices from various kinds of vegetation and they store this "honey" in their stomachs. When food is needed by a member of the ant colony, the "fat" ants regurgitate enough of the sweet substance to satisfy the hunger of the other ants. It is not uncommon to find honey ants so full that they cannot move.

Strange as some of the tasks which different groups of ants do may seem, these tasks are all an important and necessary part of the colony life. The work of the different castes is vital to the colony. D. E. Z.

SEE ALSO: INSECTA

Anus see Digestive system

Anvil see Ear

Aorta see Artery, Circulatory system

Apatite (AP-puh-tyte) Apatite is a mineral composed of calcium fluophosphate or calcium chlorophosphate or something in between the two. Its name is derived from the Greek *apate* meaning "deception" because it resembles several other minerals.

Apatite is brittle and sometimes fluorescent. It is a source of the PHOSPHORUS plants need and is a common minor part of rocks. Colorless, brown, green, white, blue, yellow or violet are the usual colors of apatite. These colors vary from transparent to translucent.

The mineral comes from some ore veins, occasional rich masses of *igneous* segregations and crystallized masses in very coarse granite. Granular beds of apatite that are mined for FERTILIZER use are found in Brazil and the Russian Kola Peninsula D. C. H.

SEE ALSO: ROCKS

Gibbon

Chicago Natural History Museum

Orangutan

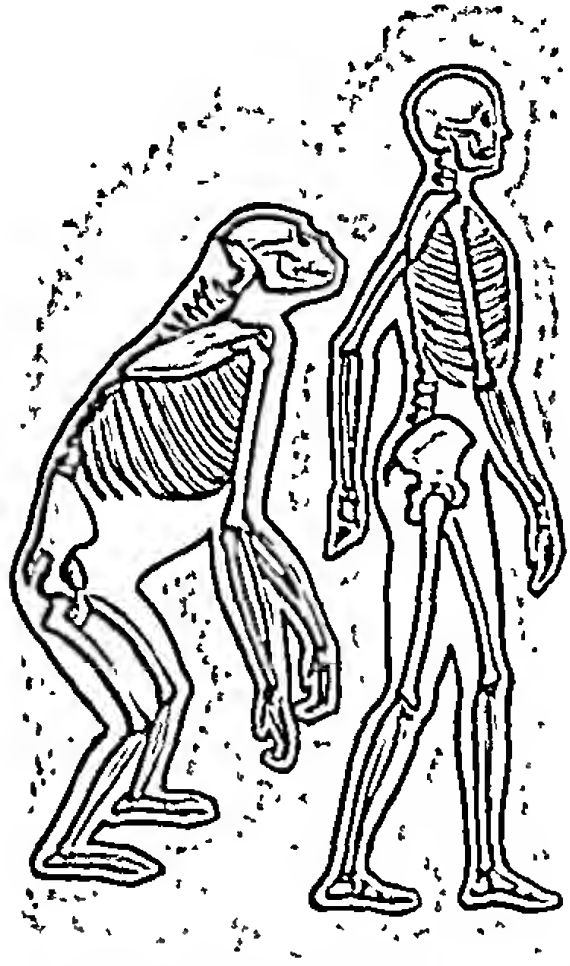
Ape Of all the animals, apes are most nearly like man. The brain, the nervous system, and the blood of apes are all quite similar to man's. The CHIMPANZEE, the ORANGUTAN, the GORILLA and the GIBBON are four groups of animals which may be called apes.

The bodies of these animals are usually covered with brown, reddish-brown or black hair except for their faces, feet, and hands. Their hands have four fingers and a thumb, which help them grasp and handle objects Since apes have "thumbs" on their feet instead of big toes, it is easy for them to use their feet just as they use their hands. They have no tails.

Though these four animals have a general physical resemblance to each other, they are in some ways different from each other. Some apes use all four limbs in walking, and others walk mainly on their hind legs. When full grown there is a great difference in the heights and weights of the four groups of apes. The gibbon seldom measures more than three feet, whereas the gorilla frequently grows to a height of nearly six feet Gorillas have been known to weigh up to 400 or more pounds when full grown.

Chimpanzee

Gorilla

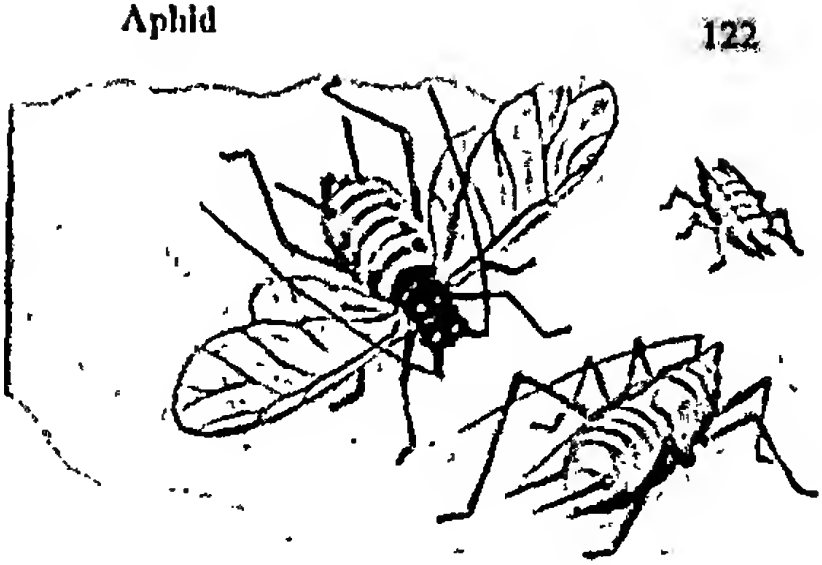


A comparison of the skeletons of man and ape reveals why man stands erect while his close relative, the ape, does not. The bones at the back of the neck on the ape keep its head thrust forward and down

Apes can climb very easily. In their natural state most of them live in trees. That is why they are *arboreal*, meaning "tree-dwellers." Some apes build nests in the branches of trees. These nests are usually made of leaves, twigs, and small branches. Apes prefer fruits and vegetables for food although they also eat eggs, small animals, nuts and insects. Apes can be found in Southeast Asia, the East Indies, Borneo, Sumatra, Central and West Africa.

Apes are gregarious animals, dwelling in family groups rather than alone. They are referred to as *anthropoids*, meaning "like man" or "resembling man." G. A. D

SEE ALSO: MONKEY, PRIMATES, SKELETON



Rose growers are familiar with the damage the tiny aphids can do to the delicate rose plants

Aphid The aphid is a small insect which attacks plants. It sucks juices from the tender cells of plant parts. Such plants as corn, oats, wheat, roses, and other bushes, plus vines and fruit trees are its common sources of food.

It has a plump body and a small head with a sharp, sucking beak. A few aphids have wings but most of them, including females, are wingless. Green, black or white are their usual colors. For protection it spreads a white, wavy secretion over its body.

While the aphid eats, it exudes sweet droplets called "honeydew" through the anus, located near the tip of its abdomen. ANTS in particular are extremely fond of this liquid and sometimes maintain whole colonies of aphids to be assured of a supply of it. If this honeydew is not gathered by ants, it appears as dew on the plant leaves. Occasionally bees will gather it when there is little pollen, but because it thins and sours quickly, an inferior honey is made from it.

An aphid does not live long, but so many generations are born in just one summer that this insect's chances of dying out are slim. The mating time is in the fall when the eggs are placed in protected parts of plants, such as between layers of bark of trees. The following spring the eggs hatch. These aphids are all females and within three to four days produce other aphids from eggs within their bodies. All during the feeding season succeeding generations are born. In the fall the last groups include males.

The destructive force of these insects is extremely great. The leaves of plants will curl up or drop off; GALL-like swellings will appear on the roots and bark whenever an aphid inhabits a plant. Fortunately, the insect has many enemies: the spider and the ladybug plus the lacewing fly, syrphus fly, and the greatest of all enemies, the chalcid fly which is itself a parasite. Beside these are the sprays which are effective in controlling the aphid. D. E. Z.

SEE ALSO: INSECTA

Apiculture see Bees

Apogee The orbit of any natural or man-made SATELLITE is never perfectly circular, nor is the Earth exactly at the center of the ORBIT. The point in the revolution of a satellite at which it is farthest from Earth is called the *apogee*.

SEE: PERIGEE

Apoplexy Apoplexy is the condition in which one loses consciousness, sensation or ability to move because a blood vessel in the brain has broken or become stopped up.

SEE: THROMBOSIS

Appalachian Mts. see North America

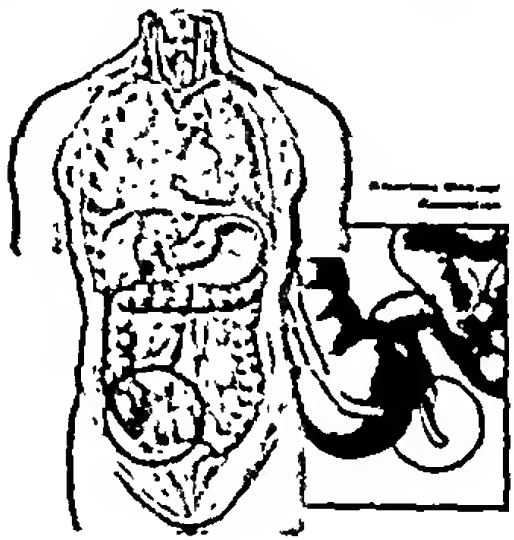
Appendages see Animals, classification of; Arthropoda

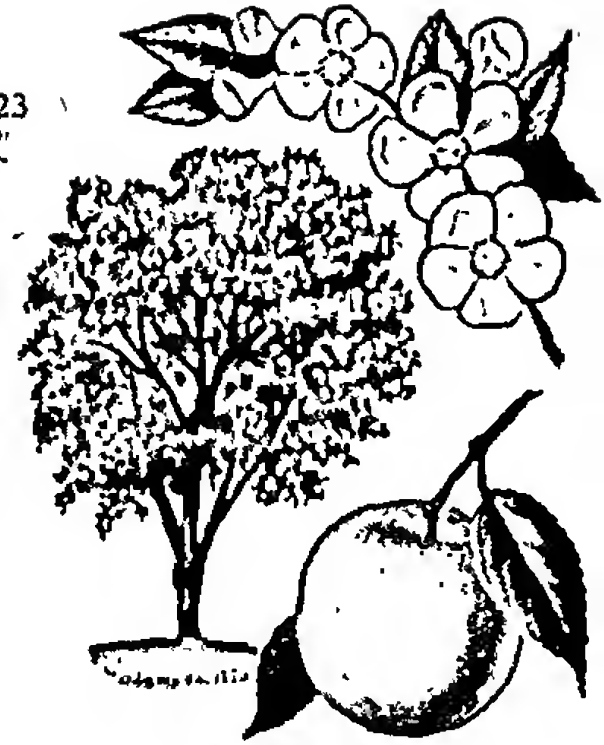
Appendix The appendix is a finger-like sac attached near the beginning of the large intestine. It is located in the lower right hand side of the ABDOMEN. The portion of the large intestine below its connection with the small intestine is called the *caecum*. There is an opening in the caecum which ends in an extension—the appendix. It may be from one to six inches in length. As far as is known, the appendix serves no useful function in the human body, but is a remainder of a useful caecum in ancestral forms.

Inflammation of the appendix (*appendicitis*) may cause severe and sometimes fatal illness. INFLAMMATION may result from infection within the appendix and may arise when bacteria collect and multiply. Infection in the appendix usually results in swelling which often makes it impossible for the materials inside to be emptied. Continued swelling, complicated by trapped toxic materials may cause the appendix to burst. The spread of the infection to the lining of the abdominal walls causes peritonitis. This can be fatal. Inflammation of the appendix may also be caused by the lodging of foreign bodies such as stones, seeds, pins or other materials within the appendix. G. A. D.

SEE ALSO: DIGESTIVE SYSTEM

The appendix is a small sac attached to the large intestine





Apple tree and fruit

Apple Apples are a valuable fruit. They can be grown almost anywhere in the world, and they provide important minerals and vitamins for the human diet.

When the first settlers came to America, they brought apple trees with them to plant in the new world. Today the United States grows more apples than any other country.

The apple is in genus *Malus* of the rose family. The tree grows to about 40 feet. The fragrant pink and white apple blossoms appear late in spring. The flower has three circles of stamens and five carpels in the ovary. When fertilized, it develops into an *accessory fruit*. The endocarp is paper-like and contains the seeds. The rest of the fruit wall is fleshy but is within the core of the apple. The fleshy receptacle makes up the major portion of the edible fruit. Most apple trees are grown by *budding*.

Over 80% of apple tissue is water and sugar. It possesses very little protein and even less fat. During the ripening process the starch molecules are changed to sugar and malic acid, which gives the sour taste, becomes less. The mealiness of apples occurs when the parenchyma cells become soft. By using yeast, apple juice can be changed to cider and then to vinegar. H. J. C.

SEE ALSO: FRUIT, PROPAGATION

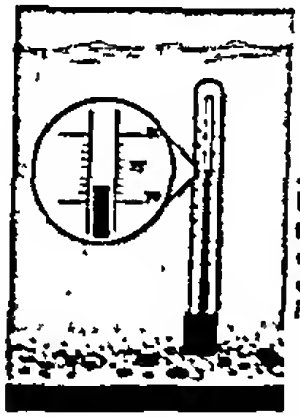
Apricot An apricot is a golden fruit which grows on a tree that gardeners have raised for hundreds of years.

An apricot tree is very beautiful, with dark green, heart-shaped leaves and white or pink blossoms. Early in the spring, the small branches of the tree are cut away so that the large strong branches can get more sun and food from the roots in order to produce much good fruit.

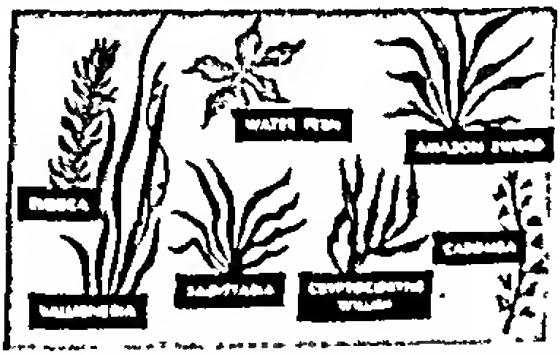
The apricot was first cultivated in Manchuria and Northern China. It was brought to Europe in the time of Alexander the Great, about 2300 years ago. Modern varieties of apricot trees growing in North China live through winters of 40° below zero.

Most of the apricots sold in the United States come from California North American varieties grown in the U.S need mild weather and considerable rain.

The apricot belongs in genus *Prunus* of the ROSE family, with the peach, plum, cherry and almond. The flowers appear in spring before the leaves. After being pollinated by insects, they develop into a FRUIT called a *drupe*. The exocarp is velvety at first, then becomes smooth. The fleshy mesocarp is yellow. The endocarp is a flat, smooth stone with a single seed rich in oil. P. G. B.

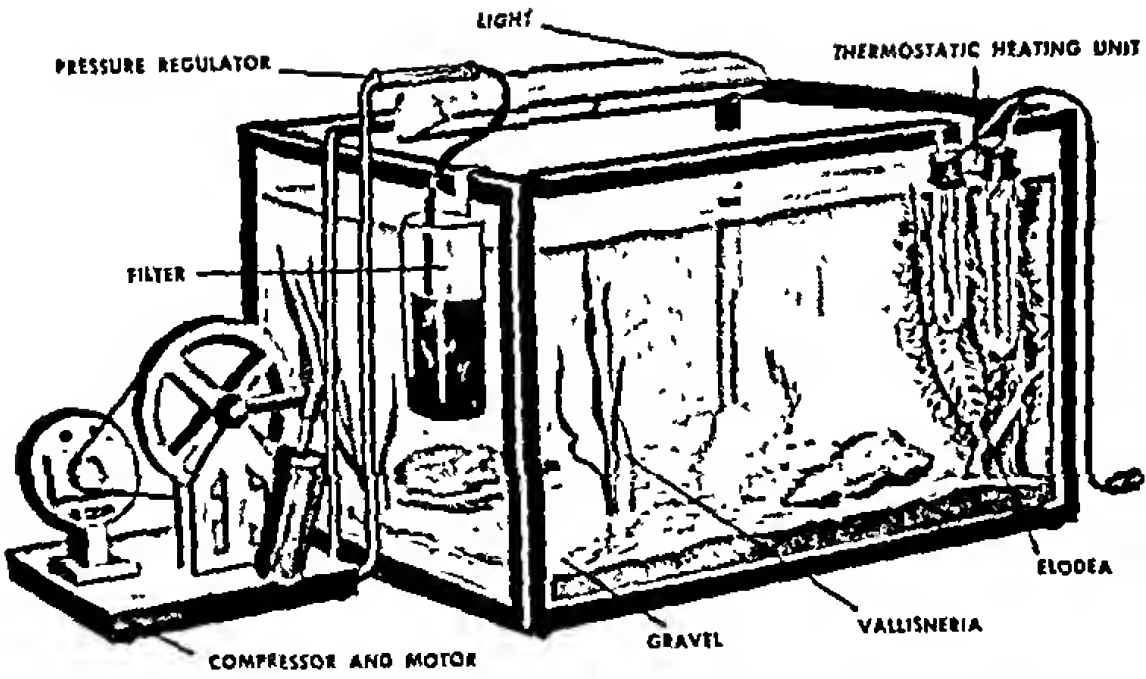


A good aquarium should be kept clean with the temperature maintained at about 72°F. A variety of water plants can live in the same aquarium



Aquarium An aquarium is a glass house for plants and animals that live in water. This glass house may be a large jar or a round bowl. It may have flat glass sides with metal edge and a glass top. About two inches of well-washed sand or gravel is placed on the bottom of the aquarium. Marbles or clean rocks can also be used. Water plants are needed in the aquarium. They not only are decoration but they give food and oxygen to the other living things in the water. An aquarium may also mean a building in which tanks of fresh or salt water animals are kept.

There are two large groups of water animals that live in a home or school aquarium. One group is called "cold water" animals. They are goldfish, tadpoles, minnows, and water insects found in streams and lakes. The water temperature for this group should be kept between 55° and 72° Fahrenheit



A typical aquarium has mechanical apparatus to aerate and control the water temperature. The light enables the plants to carry on photosynthesis and provide oxygen for the fish

The other group is made up of "warm water" animals, including all tropical fish. Some of these are guppies, platys, tetras, zebras, swordtails, mallies and angel fish. These fish like their water temperature between 72° and 80° Fahrenheit.

Some aquatic plants survive well when submerged in water. The most common are the ribbon-like grasses, Vallisneria and Sagittaria. These may be used in either cold or warm water tanks. Other desirable water plants are Hygraphia, Ludwiga, Elodea, and Cabomba. These plants must be weighted down with lead ribbons or stones to remain in a stationary and vertical position. Floating plants such as the Salvinia (fern) or Lemna (duckweed) are used in many containers. Goldfish especially like to feed on Lemna. Plants furnish the oxygen needed by the fish and in turn use the carbon dioxide given off by the fish as a raw material for PHOTOSYNTHESIS. Plants also serve as hiding places for baby fish.

Cold water animals need more space and surface area than tropical fish. A general rule is to keep an inch of fish to a gallon of water. This margin of safety may be reduced if mechanical aeration is used.

The water for an aquarium should be free of chlorine and other chemicals added in water filtration. Allowing the water to stand for one day will let these chemicals dissipate. In some areas the water should be checked to see what amounts of acid or alkali are present. A special water softener or baking soda (½ teaspoon to 10 gals of water) may be used for overly acid water. After this settling period, the fish may be added. A few snails may be included to act as scavengers in keeping the aquarium clean.

Temperature is an important factor to a plant and animal life tank. The larger the tank the less rapid is the cooling of water, especially if thermostatically controlled heaters are not used and room temperature changes radically within a 24 hour period.

M. E. C.

SEE ALSO: PLANTS, AQUARIUM; TROPICAL FISH

Aquarius see Water Bearer

Aquatic life see Marine biology

Aqueduct see Bridges, Irrigation

Aqueous humor see Eye

Aquila is "The Eagle"

Aquila (uh-KWIL-uh) Aquila means "eagle." It is the name of a group of stars that seem to form a picture of an eagle in the sky. Aquila is a summer CONSTELLATION. It can be seen from spring to autumn, but it is most easily located in summer. It lies in and around the Milky Way.

The four main stars of this constellation form the shape of a T. If modern astronomers were naming this constellation, they probably would call it an airplane. But many years ago it was compared to an eagle by the people of several different nations. The Hebrews, the Greeks, the Romans, and the Arabs all thought it looked like an eagle.

Altair, the brightest star in the constellation, is at the cross-point. It is one of the twenty brightest stars in the sky With two other very bright stars, Vega and Deneb, Altair forms a large triangle known as the Summer Triangle.

Altair is a bluish star and it has a smaller star on each side of it. This line of three stars makes the Eagle a fairly easy constellation to find in the summer. C. L. K.

Arachnida (uh-RAK-nid-uh) Arachnids are a class of animals. Their bodies are made up of two parts and they have four pairs of jointed legs. Spiders, mites, ticks and scorpions belong to the arachnid class. They are different from insects because they have no wings or feelers (antennae).

Arachnids, as a rule, have claws, poison glands, and fangs or stingers. The SPIDER differs from other arachnids in its ability to secrete a flui from which it spins a web.

The most common homes of arac nids are in warm dry regions, but som varieties may be found in almost a climates. Some live in fresh water.

Most arachnids are harmless creatures Some help man by destroying harmful in sects. Other varieties are damaging to ani mals and plants. These include the black widow spider, whose bite can be harmful to man. SCORPION stings are also painful. Some kinds of TICKS and MITES are disease carriers. Other mites do damage to plants by sucking their juices.

The arachnid's body has an outer skeleton—*exoskeleton*—on the abdomen and on the combined head and thorax. The exoskeleton is made up of chitinous tissue which serves as an attachment for the complex muscular system.

Internal body structure of arachnids follows the general pattern of other animals. The digestive system is made up of three parts which resemble intestines of other animals. The circulatory system includes a tubular heart. Some varieties breathe by means of tracheal tubes. Other have one or more pairs of *book lungs* (parallel air pockets) which receive air from a slit in the body wall.

Arachnids have a brain and central nervous system. Touch is their most highly developed sense. Sensory hairs for touch may be found on all parts of the body. Arachnids have simple rather than compound eyes. Scorpions have as many as ten pairs of eyes.

The sense of smell is poorly developed. Hearing ability has not been determined. However, some arachnids have sound-making devices. This would indicate that they are able to hear.

The garden spider is a common arachnid

Courtesy Society For Visual Education, Inc

✳ THINGS TO DO

KEEPING ARACHNIDS AS PETS

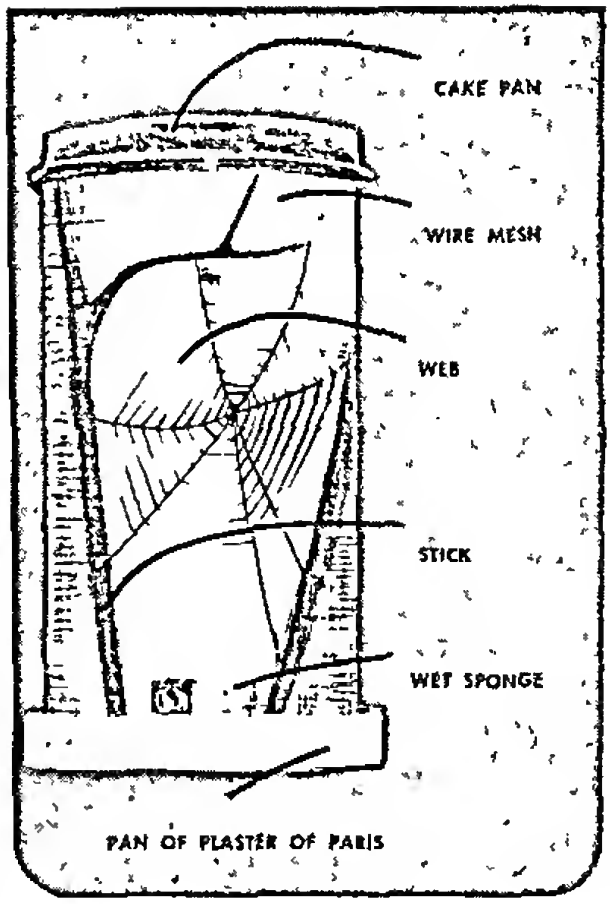
Materials: two cake pans, fine wire mesh, plaster of Paris, branching sticks

1 **Construct a cage by putting a cylinder of fine wire mesh upright in a cake pan of wet plaster of Paris. Allow it to harden. Use the other cake pan as a removeable cover. Insert several sticks for spiders to attach their webs.**

2 **In the grass of open fields and under logs or rocks, many species of arachnids may be found. Capture them in a jar to transport back to their new home. In the fall the egg cases of spiders may also be collected.**

3 **Arachnids need water daily but may go for weeks without food. Keep a wet sponge in the cage and occasionally drop in live, soft-bodied insects or meal-worms for food.**

4 **Arachnids are fascinating animals to observe. They will live and reproduce in captivity.**



Reproduction of arachnids is by means of eggs. The female arachnid lays a great many eggs at once. Some varieties, including spiders, form an egg sac to protect their young until after they are hatched.

Arachnids have been classed by scientists into sixteen different orders, five of which are extinct. The name "arachnid" is from a Greek word *arachne* which means "spider."

I. H. S.

SEE ALSO: ARTHROPODA

Arboretum An arboretum is a garden of trees and shrubs. It is divided into sections for different families of trees and other plants. Flowering trees may be in one section, nut groves in another, and evergreens in still another. The purposes of such a garden are to give scientists a place to try out new ideas and to give nature lovers a place where they can see a great many varieties of trees and shrubs at once.

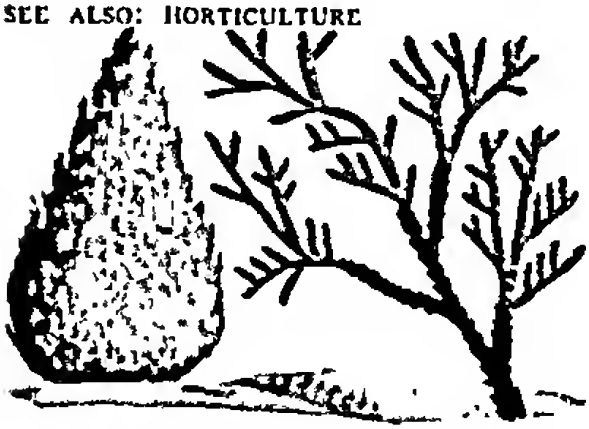
The idea of arboretums is not new. As far back as 2800 B.C. arboretums flourished in some Eastern countries. However, it was not until the middle of the eighteenth century that influential men gave money for the development of such gardens. Some of these were in France, London, England, and Japan. The first arboretum in the United States was the Linnaean Botanical Garden started in 1793, and its influence on future arboretums was very great. In America, three of the most famous ones today are the Arnold Arboretum in Boston, Massachusetts; the Morton Arboretum in Downers Grove, Illinois; and the National Arboretum in Washington, D.C.

All arboretums are not alike. Some have a representation of all the trees and shrubs common to that region. Others have only certain types of trees. Most arboretums are arranged so that all the members of one plant family grow in one section and those of another species grow in the next section. New and rare plants are also raised, and various experiments are made with different kinds of soil. In one respect all arboretums

are alike, for they pass on the information they have learned to other arboretums and to scientists.

The values of such a garden are many. They include growing a complete collection of one set of plants, testing and introducing new plants, providing a laboratory for botanists, helping schools, conserving the plant life of the region, training gardeners, and giving information to other institutions and agencies. D. E. Z.

SEE ALSO: HORTICULTURE



The arborvitae is a conifer of the north

Arborvitae (AHR-ber-VY-tee) Arborvitae is the name given to some kinds of cone-bearing trees and shrubs belonging to the cypress and cedar family. They have flat branches with small overlapping leaves. RESIN glands similar to oil glands of the skin are located on the leaves. The twigs are covered with tiny scales. Cones are always small, seldom growing to more than one-half inch long.

Arborvitae resemble CYPRESS trees. They grow mainly in north temperate regions. The northern white CEDAR, a variety of arborvitae found in the New England and lake states, does not grow to a large size. The western red cedar, in contrast, is a giant arborvitae. Its native habitat is the forests of Washington and Oregon. It often grows to a height of two hundred feet with a trunk diameter of from four to six feet.

The wood of arborvitae is light, soft, and fragrant. It is resistant to decay and is used for the manufacture of shingles and fence posts. The giant arborvitae is used in the uction of boat hulls. The fibers of bark are used for weaving mats and ets I. H. S.

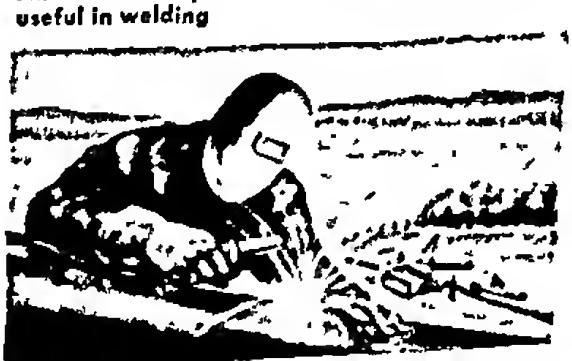
Arc When an electrical current flows from one ELECTRODE to another electrode by jumping across an air gap, an *arc* is created in that small air space. The electrode may be a wire or any material which can carry a current.

Three common properties of electric arcs are: 1) they reach very high temperatures (thousands of degrees centigrade in some applications); 2) they concentrate a high heat energy; 3) they usually produce a brilliant light. Electric arcs have applications where extremes of heat and light are required.

Arc furnaces are used in foundries and steel mills to melt metal. The arc furnace is employed for melting smaller batches than other type furnaces normally melt. The electrical current is passed from an electrode through an arc to the metal being melted. The metal acts as the other electrode and completes the electrical circuit.

Arc lamps, or *carbon arc lamps* as they are normally called, usually consist of two pure carbon electrodes which, when properly adjusted, give off an intensely bright light. Sometimes the arc is in a gas or vapor which also becomes illuminated and adds still further to the brightness. Carbon electrodes have a very high resistance to current flow, but once the current does start by touching the electrodes together, the resistance decreases rapidly. Current limiting controls must be provided for carbon arc applications. As light is produced from the arc, the carbon electrodes are slowly burned away. In order to maintain maximum brightness, the width of the gap must be adjusted constantly, either by hand or by an automatic device. Lamps of this type are used in movie projectors, searchlights and blueprint machines.

An electric arc produces very high temperatures useful in welding



Arc welding is a welding process where the highly concentrated heat of the electric arc is used to melt and join metals. Electric arc welding can be accomplished by four different methods:

1) *Carbon electrode arc*—two carbon electrodes at a slight angle to one another provide an arc to melt the joint. A filler metal can be added. 2) *Metal arc*—the most common form of welding consists of a metal rod used as one electrode, and the metal to be welded serving as the other. The rod is covered with a special coating to prevent slag from forming. 3) *Submerged metal arc*—the arc is buried in a mound of granular fusible material. This is used for large, heavy welds. 4) *Inert gas-metal arc*—a stream of inert gas (argon or helium) surrounds the metal arc to shield against the formation of impurities and spatter. This is a fast, high-quality weld. E. I. D.

Archaeopteryx (ark-ee-OPP-tuh-ricks) The archaeopteryx is one of the oldest animals known to have wings. It lived in the age of the DINOSAURS about 125 million years ago.

The name means "*ancient wing*," for the animal is considered the forerunner of the modern birds, although it had many reptile-like features. Skeleton and feather FOSSILS found in rock show the archaeopteryx to have been about the size of a crow, with a long tail and perching feet. The head was *flat with large eyes and teeth instead of a beak*. The bird was able to flap its wings and glide from the tree top but probably was not capable of long flight. A. P. M.

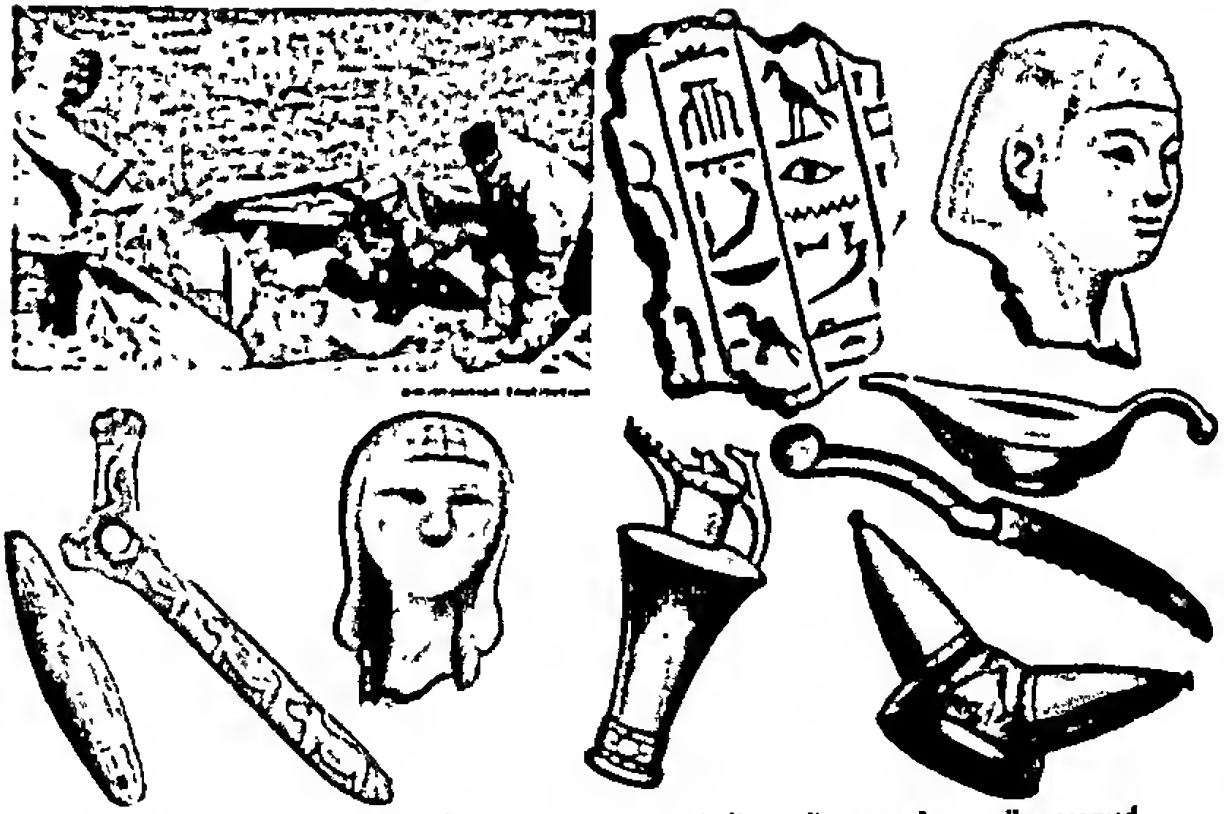
SEE: GEOLOGIC TIME TABLE

Reconstruction of an archaeopteryx

Indian relics found in the Southwest show facts about tribal cultures of long ago. Archeologists can reconstruct customs from such finds

Archeology (ark-ee-OHL-oh-gee) Archeology is the study of ancient times by means of the tools and other objects left behind by early man. The archeologist searches for man-made objects (*artifacts*), such as arrowheads and pottery jars, and tries to figure out how and when they were used. In the Americas archeologists study the culture of Indians who lived before the arrival of Columbus. In other parts of the world they search for buried cities or caves and campfires of the first men on earth.

Spear heads, axes, knives, scrapers, jars, ornaments, household utensils, furniture,



Archeologists seek remains of ancient Americans. Indian relics are often well preserved

foundations of houses, temples, ruins of a village burying ground, carvings on cave walls, and the bones and shells around a campfire can tell something about the people who made and used them. Some of these are found accidentally when people plow fields, build roads, or dig pits. Other discoveries are based on careful exploration.

Artifacts are best preserved in desert sand, in dry cold, in continuously frozen soil, and in peat bogs. Dry sand has preserved for more than four thousand years all the treasures, even linen cloth, in the Egyptian tombs. Meat of the extinct mammoth found in the ice was edible after more than ten thousand years of refrigeration.

It is the task of the archeologist to supervise the careful excavation of these finds. Sand and soil, in many cases, must be removed gently, by hand, so that none of the objects will be disturbed and so that their exact positions may be recorded. The second step—accurately cataloguing, describing, illustrating, and photographing—is a most important one. These are the clues needed to make comparisons and to reconstruct the history of the men who lived so long ago. Many objects need special treatment to preserve them. Archeologists also have been engaged in the restoration of ancient temples and palaces.

Archeology traces the history of ancient tribes of men through the tools they made. Stone Age men used stones, flint, and the bones of animals to make axes, arrowheads, needles, spears and harpoons. Polished stone implements have been found along with other objects that indicate New Stone Age man had begun to cultivate crops, raise animals, and make pottery. The people of the Bronze and Iron Ages had learned to mold metals.

The spears and scrapers of the American Indian are named from their shape and the location of the early finds. "Folsom points" are fluted spear heads found near Folsom, New Mexico. At Sandia Cave near Albuquerque, spear points and the bones of extinct Ice Age animals were scattered around two fire pits. An ancient kind of pod corn was found in another cave.

In the 19th century, excavations of Pompeii and Herculaneum in Italy uncovered these cities that had been buried for seventeen hundred years after the eruption of Mount Vesuvius in 79 A.D. These discoveries opened up the exciting field of archeology.

Some of the work done after the finding of Pompeii has laid a firm foundation for modern archeological studies. An Englishman, Flinders Petrie, and an American,

James Breasted, were among the many who uncovered the ancient tombs and temples of Egypt. The deciphering of the Rosetta Stone by Jean-Francois Champollion gave scholars the key to hieroglyphic inscription—the writing of long-lost languages. E. H. Thompson discovered the sacred well of a Mayan city in the jungles of Yucatan. Heinrich Schliemann found nine cities of Troy, each one built above the ruins of another.

Many ways have been devised to determine the age of artifacts. The nine cities of Troy illustrate the principle of super-position. Those on top are the youngest, or newest, and the lower layers are the oldest. Rocks are found in layers, or strata, and annual layers of pebbles and sediment are deposited in lakes. By this system of *stratigraphy*, man-made objects are dated according to the layers in which they are found.

Finding bones of animals known to have existed only during the Ice Ages helped determine when the Folsom and Sandia weapons were used. Calendars have been made by analyzing pollen grains preserved in peat bogs and by matching growth rings of trees.

The ancient Rosetta Stone bore inscriptions in Greek and Egyptian. It was discovered in 1799

Chicago Natural History Museum

A cut-away of the Hopewell Indian burial mound from 100 A.D. shows levels of buried artifacts

Dr. Willard Libby discovered it was possible to determine how long ago bits of charcoal or bone had been burned in a campfire by measuring the amount of carbon-14 (C^{14}) still remaining in the samples. A mammoth tusk from Sandia Cave dates back 26,000 years. This C^{14} process dates some corn pods taken from the cave to be about 5,000 years old.

Samples taken from the walls and floors of burned buildings can be dated by measuring the direction of the magnetic particles in the material. The heat of light given off by reheated lava rocks compared with the amount of radioactivity will sometimes give the age of the rocks. The amount of water absorbed by obsidian, a glassy stone used by the Indians, will tell the age of the scrapers. Ancient Grecian glass has been dated by counting the crusted rings formed on the surface.

Archeology is related to and dependent on history, ANTHROPOLOGY (the study of man), PALEONTOLOGY (study of ancient forms of life), paleobotany (study of ancient plant life), GEOLOGY (study of the earth's crust) and other sciences which reconstruct the way man lived in earlier times.

Archeological expeditions are organized and financed by governments, museums, universities and foundations. The construction of large dams and highways threatens the loss of many areas rich in ancient artifacts. A cooperative effort is under way to preserve some of the Egyptian temples. In the United States, federal and state highway projects employ archeologists to aid in the recovery of Indian remains.

New discoveries are being made in all parts of the world. These are described in geographic, archeological, and scientific magazines.

A. P. St.

SEE ALSO: PALEONTOLOGY, STONE AGE

Archeozoic Era (ahr-kee-uh-ZOH-ick) Archeozoic Era is the name given to the period in the earth's history to which the oldest rocks belong. It is thought that some form of plant life was present at that time.

The lava rocks and sediments from the Archeozoic Era, dating from two to one billion years ago, are found all over the world—in Canada, northern Europe, Australia, Africa, and in North and South America. Dating from radioactive minerals has shown rocks of this age to be at the base of or eroded on the surface of the Adirondacks, Colorado Rocky Mountains and Black Hills, and in the Grand Canyon. The presence of gold and silver has increased the search for Archaean (the very oldest) rock.

No fossils have been found in these rocks, but some formations in the limestone are believed to be evidence of some kind of sea plant. The presence of graphite, or lead, has been suggested as another clue to the existence of plant life in this era.

Geologists distinguish two kinds of ancient rock formations—the upper sedimentary Timiskaming rocks, and the lower, or Keewatin, greenstone rocks. The lower rocks sometimes have a peculiar "pillow" shape caused by lava dropping into water. These are deformed and changed (metamorphosed) so that the original composition is not known. Granites, gneisses and schists are found in this group.

During this era, the oldest mountains in North America, the Laurentians in Canada, were formed.

The Archeozoic Era is followed by the PROTEROZOIC ERA. These are the two divisions of the Cryptozoic (hidden life) Era and are often designated as subdivisions of Pre-Cambrian time. A. P. M.

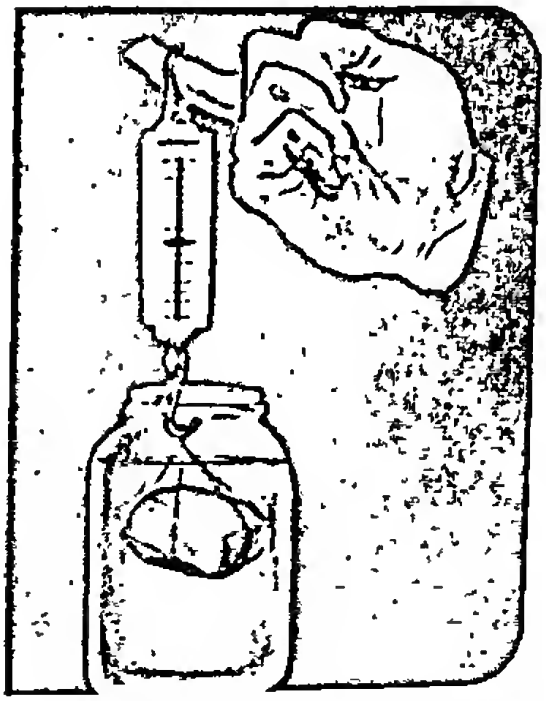
SEE ALSO: GEOLOGIC TIME TABLE, ROCKS

Archimedes (287?-212 B.C.) (Ar-kih-ME-deez) Archimedes was a Greek scientist and mathematician. He is famous for his work in geometry, physics and mechanics.

He discovered a principle, known today as *Archimedes' principle*, which states that a solid object when immersed in a liquid is buoyed up by a force equal to the weight of the displaced liquid. It is said that Archimedes discovered this principle in a most unusual way. The king of Syracuse suspected his goldsmith of dishonestly mixing silver with the gold for the royal crown. He commanded Archimedes to discover whether the crown was of pure gold. Archimedes pondered how he could measure the gold in the crown without actually melting it down. The answer came to him as he lowered himself into the tub at one of the public baths in Syracuse. He noticed that a certain amount of water spilled over the sides of the tub. Excitedly he realized that he had discovered the way to fulfill the king's command. He realized that the apparent loss of weight of an object immersed in water must be equal to the weight of the water displaced by the object. Why not use the same principle to find the amount of gold in the crown? Since gold and silver are of different densities, each would show a different apparent weight when immersed in water. A pure gold crown im-

✳ THINGS TO DO

PRINCIPLE: AN OBJECT IN A LIQUID IS BUOYED UP BY A FORCE EQUAL TO THE WEIGHT OF THE LIQUID IT DISPLACES



Weigh a rock with a spring scale. Put it in a jar of water. One cubic foot of fresh water weighs about 62.3 pounds. How much does the rock weigh now? What is the buoyant force on the rock?

✳ THINGS TO DO

PRINCIPLE: DECREASING DISPLACEMENT WILL DECREASE *THE BUOYANT FORCE.* AIR MAY BE COMPRESSED BUT WATER CAN BE COMPRESSED ONLY SLIGHTLY

1 **Turn a small bottle upside down in a large bottle of water. Push down on the cork of the big bottle.**

2 **Water forces the air inside the inverted floating bottle to become compressed. The volume of water displaced by the bottle is decreased. The buoyant force is decreased and the *bottle goes to the bottom. When the* cork is lifted the opposite occurs. The bottle rises to the surface.**

mersed in water would weigh more than one of the same volume containing silver. The experiment was carried out and the goldsmith was found guilty. He was quickly executed.

Archimedes was the inventor of some of the most devastating machines of war known to his age. The siege of Syracuse by the Romans lasted three years chiefly because of the genius of Archimedes. Archimedes met an untimely death when Syracuse was finally captured by the Romans. D. H. J.

Archipelago (ark-eh-PELL-uh-go) An archipelago is either a body of water containing many ISLANDS or the islands in such a body of water. For example, the Aleutian Islands west of Alaska form an archipelago.

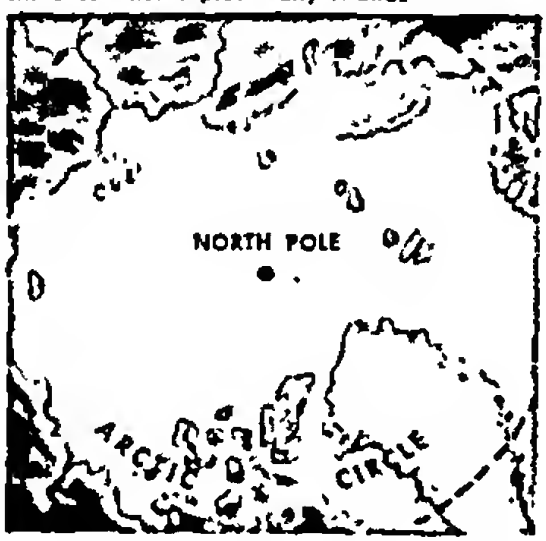
Arctic (ARK-tick) The Arctic is an area which includes a sea, many islands, and the northern parts of Alaska, Siberia and Canada. It lies around the North Pole, some of it within the *Arctic Circle* and some not. The region is treeless. There are mountains and plains covered in summer with mosses, tiny flowering plants, and grasses called TUNDRAS. Part of the land and sea is always ice capped, and even ice-free summer ground is frozen several feet deep.

Of the outlying islands near the Arctic Circle, only those with mean temperatures of not more than 50°F in summer and 32°F in winter are called *arctic*. Surface travel is generally easier over frozen terrain, during winter, but in summer, surface melting makes travel difficult. Thus modern exploration was begun by water. ROALD AMUNDSEN of Norway first discovered a northwest passage (1903-1906). James Ross located the *magnetic north pole* in 1831, ROBERT PEARY, reached the *geographic north pole* in 1909. Since then, most land masses have been charted, and scientists are now mapping the ocean floor. Others are operating new weather stations on drifting ice islands to study the arctic weather.

Small salt lakes open up during summer in the Arctic Ocean. In August, 1958, the U.S. nuclear submarine *Skate* surfaced nine times in such lakes. During winter, even these salt lakes may freeze; but in March, 1959, the *Skate* broke through the ice cap at the North Pole.

The Arctic has special importance because many *great circle aircraft routes cross it.* It is militarily vital because the United States'

The Arctic Zone includes the northern tips of three continents plus many islands



Distant Early Warning system (DEW line) has a series of aircraft and missile detectors across the Canadian and Alaskan Arctic.

Arctic waters are rich in crabs, jellyfish and plankton, so fishes, seals and whales are abundant. The land yields valuable minerals including uranium ores. E. R. B.

SEE ALSO: EARTH, POLES, INTERNATIONAL GEOPHYSICAL YEAR; GLACIERS

Arcturus see Bootes

Area Area is the measurement, in square units, of the amount of *surface* included within given boundary lines.

SEE: GEOMETRY, MEASUREMENT

Argon Argon is a colorless, odorless, rather rare GAS found in the atmosphere. It makes up almost 1% of the air breathed. It is chemically inactive, so it does not form compounds with other elements. Its chief use is in the manufacture of electric light bulbs.

When an element combines with oxygen a chemical change takes place called *oxidation*. When a metal oxidizes it is in reality burning However, for a metal to oxidize it must have oxygen with which to combine. Also, when metals are heated they become chemically more active. Therefore a TUNGSTEN filament in an electric light bulb would deteriorate rapidly if any oxygen were present Argon, because it will not combine with tungsten, is an excellent gas to use in the inside of an electric light bulb

The existence of argon was suspected around 1875, but it was not until 1894 that two English scientists, Sir William Ramsay and Lord Rayleigh, isolated it Sir William named the element *argon* (from the Greek *argos* which means "lazy" or "idle") because it was chemically inactive.

Argon (symbol A) is element number 18 It has an atomic weight of 39 948 (39 944, O = 16). E. R. F.

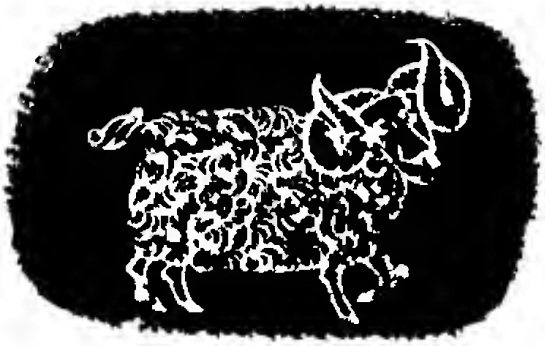
SEE ALSO ATOM, ELEMENTS

The most frequent use of argon is in electric light bulbs

Argonaut An argonaut is an eight-armed salt-water shellfish related to the OCTOPUS. It is sometimes called *paper nautilus*.

SEE: MOLLUSCA

Arid Arid means dry or lacking in moisture. Some arid land is DESERT.



Aries is an autumn constellation

Aries (AIR-eez) Aries, or The Ram, is a CONSTELLATION. It is the first sign of the ZODIAC. The Ram can be seen about midnight from June to February. But the best time to look for it is in the autumn. The three main stars of this group form a small curve. The stars of Aries are not as bright as some of the stars of other constellations.

Long ago the Babylonians, the Hebrews, the Persians, and the Arabs noticed this small group of stars and they all called it the Ram Part of the Greek myth of the Golden Fleece explains (they thought) how the Ram got in the sky. The king of Thessaly had two sons, Phrixus and Helles Their stepmother treated them badly Mercury, a god, felt so sorry for the boys that he sent a ram with golden fleece to rescue them. Phrixus and Helles were to hold onto the ram's golden fleece while he flew them through the air But when they were crossing the Hellespont, Helles lost his grip for a minute He fell into the sea and drowned That is how the Hellespont got its name The ram did carry Phrixus to safety, however Phrixus was so grateful to the gods for his escape that he sacrificed the ram to the gods Jupiter, the king of the gods, gave the ram a place in the stars in recognition of what he did for Phrixus C. L. S

Aristotle was a scientist, philosopher and teacher. In his "peripatetic" school, he and his pupils strolled around as they talked

Aristotle (AHR-eh-stot-uhl) Aristotle was a Greek scientist and teacher. He was the first person to study BIOLOGY —the science of life. He collected the first library in Europe, and he gathered together animals for the first zoo. These animals were sent to him by Alexander the Great's soldiers.

Born in Stagira in the remote northeast, in Thrace, Aristotle was the son of the court physician to the king of Macedonia. His father was one of his early tutors, giving him a sound education in the natural sciences. At the age of seventeen he was sent to Athens to complete his education at Plato's Academy. He studied under the great Plato for twenty years and was strongly influenced by his thinking. Plato called Aristotle's house "the house of the reader" because Aristotle had collected a large number of parchment scrolls. In fact, his was the first library in Europe. Aristotle was interested in all areas of knowledge known in his time. He was the first biologist. In addition, he was the first person to study all forms of life with an aim to classifying living creatures according to a system. This classification has been called his *scala natura*, a Latin term meaning "natural scale."

After the death of Plato, Aristotle was invited to tutor Alexander, the fourteen-year-old son of the king of Macedonia. This relationship lasted only a few years, but there seems to be evidence that Alexander did not forget his former teacher, who had taught him "the art of living." In fact, after Alexander had inherited his father's throne and had set off on his Asian expedition, he ordered several thousands of his men to collect rare specimens of animal and plant life and, together with the observations they had made, ship them back to Aristotle. By this time Aristotle had returned to Athens and was busily engaged in using these specimens to organize a great zoological garden which Alexander seems to have designed and financed.

In addition, Aristotle established his famous school known as the Peripatetic school of philosophy. The word *peripatetic* is a Greek word meaning to walk around. And this is exactly what Aristotle and his pupils did! Together they strolled along the shaded walks of the Lyceum while he talked with them. It is thought that Aristotle composed here most of his known works on natural science, metaphysics, logic, ethics, politics, rhetoric, and poetics.

In 323 B C, the year of Alexander's death, Aristotle was forced to flee Athens to a nearby Macedonian garrison. Alexander's death had released a strong surge of anti-Macedonian feeling which had built up during the period of Macedonian leadership, and Aristotle was accused of "godlessness." Exile affected him keenly and he died within the year.

Aristotle's primary interest was to answer the question, "What is the good life for man?" He reasoned that if he could observe each living thing and make complete records of his observations, he would be close to understanding life. His observations began with marine life and progressed to mammals. He worked under great handicaps, having no books to consult, no scientific instruments to use, and no one with whom he could discuss his findings. In spite of these hardships, Aristotle made countless contributions to science that later were verified. Others are still being argued. D H. J.

Arithmetic (uh-RITH-muh-tick) Arithmetic is a system of concepts and processes which man has created to determine, to record, and to communicate ideas of number and number relationships. Since it is used to think about and to exchange ideas of quantity, it functions also as a language and as a means of arriving at answers to certain kinds of mathematical questions. Because the Hindu-Arabic system of notation is used throughout the civilized world, arithmetic concerns itself with the ten digits —1, 2, 3, 4, 5, 6, 7, 8, 9, 0—and the fundamental operations as applied to this system.

The basic idea underlying arithmetic is *counting*. Counting requires an understanding of the *cardinal* (grouping) meaning of number, as well as an awareness of the *ordinal* (ordering) meaning of number. When symbols such as 2, 5, 7 are used to indicate "how many in all"—like "two," "five," "seven"—they are being used in their cardinal sense. When symbols such as 2, 5, 7 denote position in a series and convey the idea of "second," "fifth," "seventh," they are used in their ordinal sense.

The cardinal number "ten" is a property common to all groups of things that have the same number of elements. The word "ten" is not a number but a name for a number. The symbol 10 is not a number; it stands for a number. Some earlier people represented the number "three" as: Egyptian |'|, Greek γ, Chinese 三, Roman III. This shows that "three" is only a name for a number.

A system of notation for numbers is a system of symbols for writing numbers. A system of numeration is a system of number names. The Hindu-Arabic system of notation is a *decimal* system (base 10) because the grouping of symbols is by tens. It is also a *positional* system because the position in which a digit appears determines its numerical value. The numeral 43 stands for 4 tens and 3 ones. The numeral 796 stands for $7 \times 100 + 9 \times 10 + 6 \times 1$ which is equivalent to $700 + 90 + 6$. Similarly, 5802 is $5 \times 1000 + 8 \times 100 + 0 \times 10 + 2 \times 1$.

HINDU DIGITS (1050 A.D.)

0	1	2	3	4	5	6	7	8	9
०	१	२	३	४	५	६	७	८	९

In the Egyptian system of notation, a vertical staff (|) stood for 1, a heel bone (∩) for 10, a scroll for 100, a lotus flower for 1000, a pointing finger for 10,000, a fish for 100,000 and a man in astonishment for 1,000,000. This system was decimal but not positional. Any symbol could be used as many as nine times, but if ten of that particular symbol were needed, the Egyptians used a new symbol. The number 7 was expressed |||| ||| ; the number 49, ∩∩ ||||| ∩∩ ||||

EGYPTIAN HIEROGLYPHIC NUMERALS

1	10	100	1,000	10,000	100,000	1,000,000
Stroke	Arch	Coiled Rope	Lotus Flower	Pointed Finger	Tadpole	Amazed Man

The Babylonians had a system employing positional notation, but their system was not decimal. It was a sexagesimal system (base 60) because the grouping of symbols was by sixties. In the Babylonian system of notation, the number 16 would be expressed 𒌋 𒐗𒐗𒐗 𒐗𒐗𒐗 ; the number 61 as 𒐗 𒐗 (1 sixty + 1 one). Because this system was not decimal, it was impossible to know whether the symbol meant 60 or 1.

Thus it is possible for a system of notation to be decimal but not positional, as in the case of the Egyptian, and positional but not decimal as in the Babylonian.

Arithmetic deals with three classes of numbers: (1) the counting (natural) numbers, designated by the symbols 1, 2, 3, . . . (2) the common and decimal fractions (positive rational numbers), represented by such symbols as $\frac{2}{3}$, $\frac{3}{5}$, .37, 1.3333 . . . (3) the positive irrational numbers (numbers not expressible as the quotient of two natural numbers), designated by such symbols as $\sqrt{2}$, π. These classes of numbers are the numbers of arithmetic.

Arithmetic developed through the ages as a functional tool designed to meet mankind's increasing quantitative needs. In the past century mathematicians have attempted to state the basic laws of arithmetic as a logical structure. These are often called *axioms*.

Arithmetic consists of a set of elements called *numbers*. (These have been previously referred to.)

There are two binary operations, called *addition* and *multiplication*, designated by the symbols + and ×. A binary operation is one which can be performed on only two numbers at a time. Interestingly enough, it is possible to add only two numbers at a time or to multiply only two numbers at a time. To be able to add three numbers or to multiply three numbers, one must extend the ideas of addition and multiplication in their simplest forms.

It is always possible to add any two numbers or to multiply any two numbers, and the result shall be an arithmetic number.

$3 + 7 = 10$; $8 \times 7 = 56$; $\frac{1}{3} + \frac{2}{5} = \frac{11}{15}$; $\frac{1}{3} \times \frac{2}{5} = \frac{2}{15}$; $.16 \times 1.4 = .224$

Any two numbers can have only one sum. Any two numbers can have only one product.

3 + 7 equals 10 and only 10

8 × 7 equals 56 and only 56

The order of addition or multiplication of two numbers does not affect the outcome.

$3 + 7 = 7 + 3$; $8 \times 7 = 7 \times 8$

When three numbers are involved, the grouping of the numbers does not affect the result.

$$3 + 7 + 9 = 3 + (7 + 9) = (3 + 7) + 9$$

$$2 \times 3 \times 5 = 2 \times (3 \times 5) = (2 \times 3) \times 5$$

Multiplication is distributive over addition. This axiom can best be explained by an example.

$$3 \times 14 = 3 \times (10 + 4) =$$
$$3 \times 10 + 3 \times 4 = 30 + 12 = 42$$

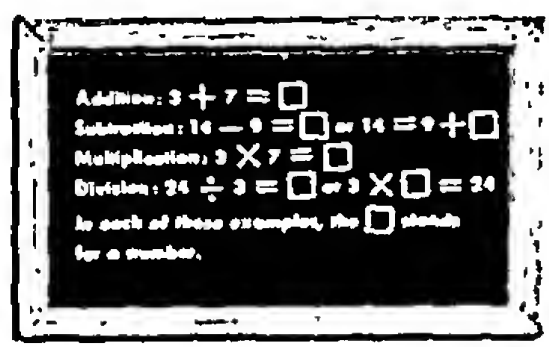
The value of any number is unchanged when zero (0) is added to it. When any number is multiplied by 1, the product is equivalent to that number.

$7 + 0 = 7$ $4 \times 1 = 4$

For every number (except 0) there is an inverse for multiplication, its reciprocal. The reciprocal of 3 is $\frac{1}{3}$. The reciprocal of $\frac{1}{5}$ is 5. The reciprocal of $\frac{3}{4}$ is $\frac{4}{3}$. Thus, one can find the sum and the product of any two numbers. Suppose that for each of these two operations there exists an "undoing" operation which brings one right back to the starting point. The number 4 added to the number 3 yields the sum 7. The number 7 "undone" by the number 4 yields the number 3. This inverse (undoing) operation is called *subtraction*. One writes $7 - 4 = 3$ and says "Seven minus four is three." One also says that the difference obtained when 4 is subtracted from 7 is 3. Notice that $7 - 4 = 3$, because $3 + 4 = 7$. When 3 is multiplied by 4 the product is 12, or $4 \times 3 = 12$. Assuming the inverse operation exists for multiplication, it is possible to take the number 12, operate on it with the number 4, and get the number 3. This inverse operation is called *division*. One writes $12 \div 4 = 3$ and says "Twelve divided by four is three." Another way of saying it is, "The quotient obtained when 12 is divided by 4 is 3." Again, $12 \cdot 4 = 3$ because $4 \times 3 = 12$.

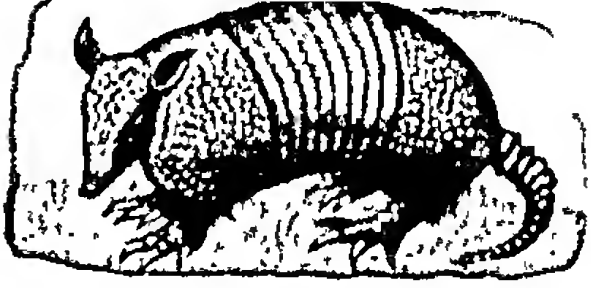
The abstract processes of arithmetic, often called *algorithms*, follow logically from the properties of our number system and the assumptions mathematicians make about number and number operations.

The so-called four fundamental operations of arithmetic are illustrated as mathematical statements or questions:



Arithmetic has wide application for the business man, for the scientist, for the nurse, for the housewife. Every walk of life uses arithmetic in one or more of its many applications. The introduction of ratio, per cent, rate, square root, and other arithmetical concepts has increased the effectiveness and usefulness of arithmetic. It has long been mankind's most faithful servant. I. K. F.

SEE ALSO: ALGEBRA, MATHEMATICS



Armadillo

Armadillo The armadillo is a mammal covered by its own "armor" for protection. The armor is made of a hard bony substance. When in danger, the animal can roll into a ball. The armadillo is also protected by strong claws. It moves about mostly at night and eats insects, roots, and fruits.

The home of the armadillo is a burrow which it can dig very quickly with its powerful claws. Armadillos range in size from only a few inches up to about four feet, but fossils of even larger forms have been found. They live mainly in South America, but some can be found in the southern part of the United States.

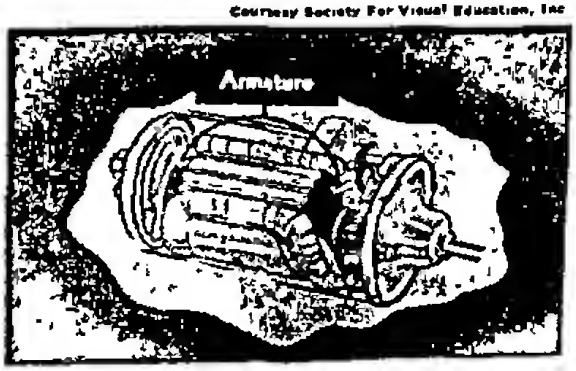
The young are born large and tough-skinned, and, unlike most mammals, they are able to see at birth. As they grow, the armor plates become solidified. *Armadillo* is a Spanish word meaning "little armored one." M. E. C.

Armament see Missile, Rocket, Weapons

Armature (AHR-mah-ture) An armature consists of many turns of insulated wire wound around a piece of soft iron. It is the armature of an electric DYNAMO or generator in which electrical energy is induced.

When a coil of wire through which a current is running is wound around an iron bar, a magnet and a magnetic field are produced for the time the current is running. When a magnetic field is cut by a wire, or cuts across a wire, a current is induced in the wire if the circuit is closed. This discovery of MICHAEL FARADAY in 1831 is at the heart of the electric generator. It is called electromagnetic INDUCTION.

Courtesy Society For Visual Education, Inc



In the direct current electric motor the *magnetic force* which operates between the armature and the field magnet causes the armature to rotate when the current passes through the armature. In the *direct current generator* the rotation of the armature causes the current to flow through the stationary field.

In an *alternating current generator* the field moves past the stationary coils of the armature. In the huge alternating current generators in use today the field magnet *(rotor) rotates while the generating coils* on the armature *(stator)* are stationary.

The armature in a generator may be turned by the power derived from coal, coke, gasoline, or falling water. I. K. F.

SEE ALSO: ELECTRICITY, ELECTROMAGNET

Arnica Arnica is a group of yellow-flowered herbs of the THISTLE family which grows in the northern hemisphere.

SEE: HERB

Arrowroot Arrowroot is a STARCH made from the RHIZOMES (underground stems) of several tropical HERBS. Since it is easily digested, it is often used in baby foods.

SEE: CARBOHYDRATE, STEMS

Arsenic Arsenic is a chemical element. Compounds of it can quickly kill many insects that destroy garden plants. Small amounts of it will make some metals harden. But, when wrongly used, arsenic chemicals are slowly poisonous to man.

Arsenic (symbol As) is element number 33. It has an atomic weight of 74.9216 (74.91, O = 16). When pure, it is a steel-gray solid. It is not found free in nature. It occurs mainly in the dark red sulfide realgar (As_2S_2) and arsenic-iron pyrites (FeSAs). Two of its important insecticide compounds are Paris green ($CuHAsO_3$) and lead arsenate ($Pb_3(AsO_4)_2$). D. A. B.

SEE ALSO: ATOM, ELEMENTS, POISON

Arteriosclerosis (are-TEAR-ee-oh-skleer-OH-sis) Arteriosclerosis describes a condition that may develop in the arteries, the vessels that carry the blood away from the heart. As people grow older their blood vessels become less elastic and do not contract and expand as easily as they did when younger. This is known as *hardening of the arteries* or arteriosclerosis.

In arteriosclerosis, there are deposits of fatty substances and, in a later stage, of calcium within the arterial walls. Improper METABOLISM of fats are believed to be responsible for the CHOLESTEROL deposits that harden and thicken the vessels.

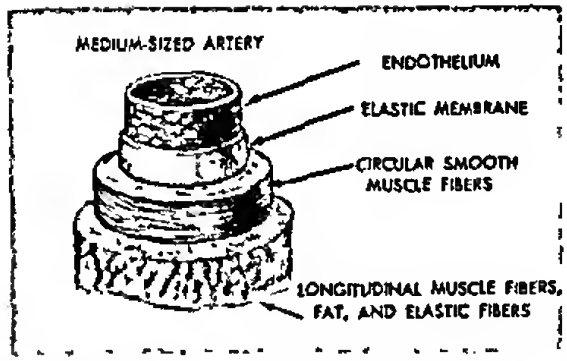
People who have *hypertension* or high BLOOD PRESSURE and are obese are often victims of arteriosclerosis. They may suffer from poor circulation, heart attacks, strokes, or kidney diseases. J. D. B.

SEE ALSO: ARTERY, CIRCULATORY SYSTEM

Artery Arteries are tubes which carry blood from the heart to all parts of the body. In man, a large artery leads from each of two chambers (ventricles) of the heart. The arteries grow smaller and smaller as they branch out and reach all parts of the body. These *arterioles* (small arteries) branch into the *capillaries*, the smallest tubes in the blood system. They in turn enlarge into venioles and VEINS. The veins return the blood to the heart. This completes the circle the blood takes through the body.

The *pulmonary* artery leaves the right ventricle and branches into two arteries, one going to each lung. These arteries carry blood with an excess of carbon dioxide, a waste to be eliminated. The *aorta* leads out of the left ventricle and arches back over the heart. It is one inch in diameter and has very thick walls. It begins the work of carrying food and oxygen to all parts of the body.

The beating of the HEART propels blood through the arteries. The artery walls contract and expand to accommodate the flow of blood. This artery wall movement is called *pulse*. It can be felt inside the wrist and at other points on the body where an artery lies close to the surface.



The arteries carry blood from the heart to the body. They are made up of three layers of tissue that control the vessel size

Artery walls have three distinct layers. The outer coat is an elastic connective tissue which provides resilience under pressure. The middle layer is composed of smooth muscle, which can change the size of the vessel opening and therefore the amount of blood it can carry. The inner layer is a thin membrane lined with smooth cells which reduce friction as the blood flows through the artery.

The word *artery* means "air pipe." Arteries were so named because of the ancient belief that air rather than blood passes through the body. I. H. S.

SEE ALSO: CIRCULATORY SYSTEM

Artesian well see Well

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Many diseases have arthritis as part of their symptoms. Some of these are tuberculosis, syphilis, pneumonia, rheumatic fever, gonorrhea, dysentery, gout and infected teeth or tonsils.

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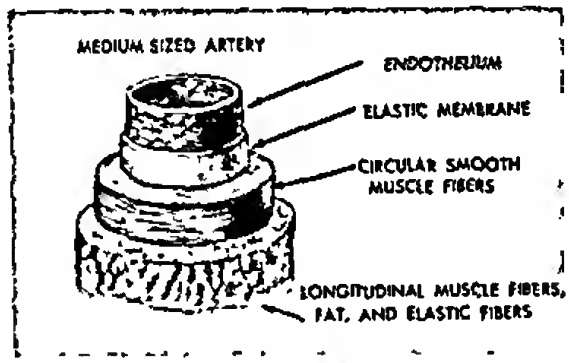

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Gout produces a type of arthritis due to faulty PURINE metabolism. Salts of uric acid are deposited in the joints, especially in the large toe and there is irritation of the tissues. Some common and mild illnesses that produce pain and stiffness of the joints are often called *rheumatism* or lumbago. The muscles and surrounding connective tissue structures are tender but the joints are not directly affected.

Rheumatoid arthritis is a serious type of inflammation of the joint. The cause is unknown. One of its characteristics is the symmetrical joint involvement. The knuckles of the hands are most often affected and if a finger of one hand is involved the same finger on the other hand also becomes involved. The joints are swollen and painful, movement is limited, and deformity sometimes results. Rheumatoid arthritis usually affects the entire system of joints throughout the body.

In *osteoarthritis*, the weight-bearing joints are most often involved and the end joints of the fingers may become enlarged. This degenerative disease is chronic with destruction of cartilage and compensating overgrowth of bone. As the joints become less movable pain appears late in the course of the disease.

There is no known cure for rheumatoid arthritis or osteoarthritis, but rest, prescribed exercises, massage, heat and some medications (ASPIRIN, ACTH, CORTISONE) are effective treatments. *D. C. H.*

SEE ALSO: JOINTS, SKELETAL

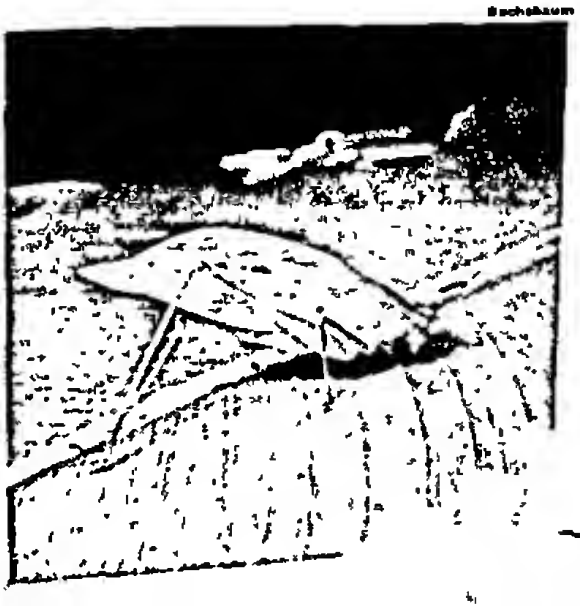
Arthropoda Arthropods are a very large group of animals with jointed legs. A joint is important to an animal. It joins two parts of the body and allows these parts to bend. A person would not be able to run, skip or jump if his legs and feet did not bend at the joints.

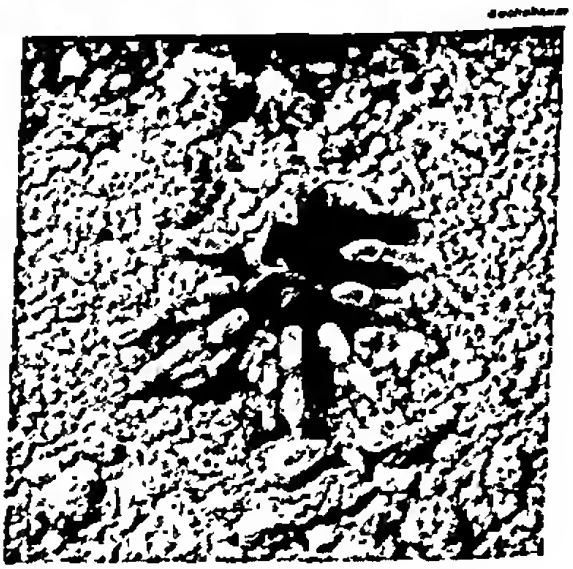
Arthropods are able to walk instead of crawl. The legs are under the body. They lift the body off the ground, so that the arthropod is able to move very fast. The joints allow greater freedom of motion.

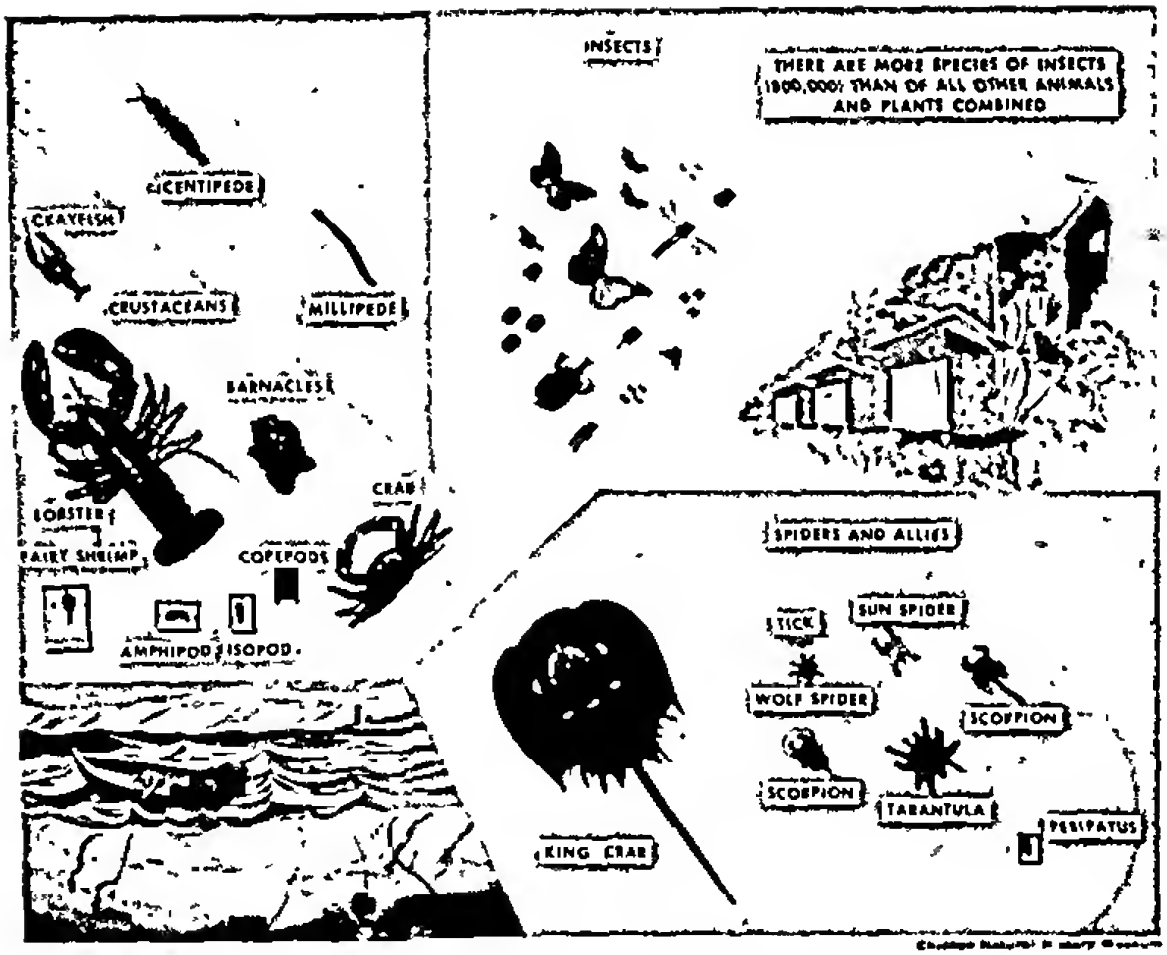
Most arthropods are well known. Lobsters, shrimp, crabs, spiders, insects, mites, ticks, centipedes, and millipedes are some animals in this group.

These animals are very successful in this world. Some live in the ooze at the bottom of the ocean. Some fly through the air. Others are found in fresh water, on land and in soil. They are found in most parts of the world. They eat the largest number of plants and animals. They eat the most un-

Phylum *Arthropoda* is the largest and most varied group of animals. The delicate and usually harmless katydid (lower left) belongs to Class *Insecta*. The poisonous tarantula (lower right) belongs to Class *Arachnida*







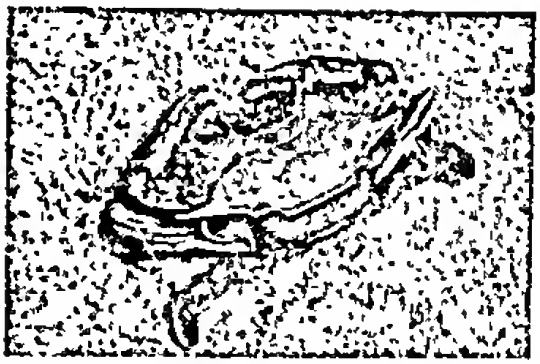
usual foods, such as cloth and wooden buildings. They have special body parts for protection against their enemies. Their thick outer skeleton is made of a material called CHITIN. It protects the soft body underneath. Different animals have pincers, large eyes, antennae, stingers, and poison claws. Arthropods are so successful, that four-fifths of all the known animals in the world are members of the group.

Many of the larger animals depend upon arthropods as food. Since many arthropods feed upon plants, they change large amounts of the plant protoplasm into useable food for other animals. For example, insects are food for such animals as fish, birds and reptiles. Lobster, shrimp and other aquatic animals are food for man.

While many arthropods are of benefit to man, others are harmful. The BEES and other insects cross-pollinate flowering plants. Silk is provided by the SILKWORM and the spider. However, CRAYFISH destroy cotton and corn crops in the southern states. Some insects destroy fresh meat and plants. Blood-sucking mites and ticks transfer diseases Arthropods are so numerous in many places that they make life difficult or even impossible for man.

An outer covering, or *exoskeleton*, of chitin protects the soft inner tissues of the arthropod. Chitin is as important to the arthropod as steel was to a knight in armor. This exoskeleton is constructed like a suit of armor. To enable a knight to bend his body, the suit of armor had to be made with moveable steel plates. The armor-like exoskeleton of the arthropod is composed of moveable chitinous plates.

In body structure, the arthropod may be compared to a passenger plane. On the inside, the plane is divided into many compartments, such as control rooms, passenger lounges and storage rooms. From the outside the plane appears to have only three main parts, the nose, the main body, and the tail sections. The outer structure does not reveal the inner structure. It would not be practical for a plane to be constructed in moveable sections, like those of a train. The three main sections are fused together so that they move together. In the same way,



Courtesy Society For Visual Education, Inc.

A thousand kinds of crabs are in Class *Crustacea*

Courtesy Society For Visual Education, Inc.

Honeybees (of Class *Insecta*) on a sumac branch

the arthropod body consists of segments, or inner divisions, which are fused together to form three main outer body parts—the head, thorax, and the abdomen.

Several segments are fused together to form the head. Except for the first segment, each segment has a pair of jointed appendages, such as jaws for biting or sucking, antennae for feeling, or claws and mouth parts for capturing and ingesting food. Eyes are also located on the head. The simple and compound EYE may both appear on the same animal. The compound eye is unique to the arthropods. It is made up of many complete units, each with a separate lens.

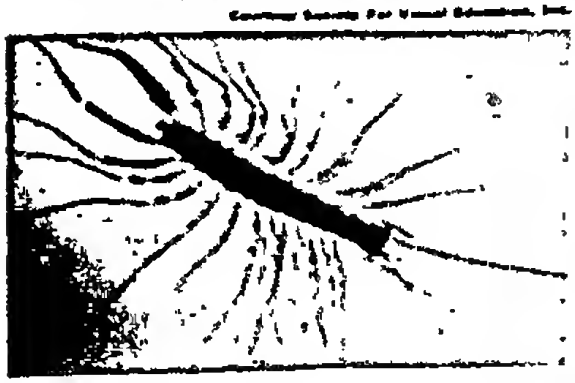
The appendages for locomotion are located on the thorax. Each type of animal has a definite number of appendages. The arachnids—spiders, ticks and mites—have four pairs of walking legs, while the INSECTS have three pairs of walking legs and two pairs of wings. The abdomen usually contains the anal and reproductive openings. Appendages may also be present on the abdomen.

Arthropods have systems for transportation of messages or substances throughout the body. A brain and nerve cords make up the nervous system. The inner nervous system connects with outer sense organs, such as eyes, antennae, hearing organs, sensory bristles and hairs. A simple heart and a series of blood vessels leading into open spaces throughout the body make up the blood system. The digestive tube is lined at the mouth and anus with chitin. Digestion takes place in the middle section. Excretory organs often empty into the digestive tube. For breathing, most land arthropods have a system of tubes lined with chitin, which are called *trachea*. The tubes open to the surface and air circulates to the inner tissues. Most aquatic arthropods, like the lobster, have gills.

Among arthropods, the sexes are usually separate. Arthropods lay many eggs. Since the adult may develop within a few days or weeks, there may be several generations a year. All larva develop into adults by MOLTING their outer covering several times before they reach adulthood. E. P. L.

SEE ALSO: ANIMAL; ANIMALS, CLASSIFICATION OF; ARACHNIDA; CRUSTACEA; INSECTA; METAMORPHOSIS; MILLIPEDE

The centipede is in a class by itself



The *American locust* is also of Class *Insecta*

Artichoke

Artichoke The fleshy center of the flower bud is the part of the artichoke plant that is eaten as a vegetable. The tough outer part (the *bracts*) is discarded.

This perennial herb thrives in milder climates, as the rootstock of the true *burr* or *globe* artichoke does not survive cold weather. New plants are grown from sprouts rather than seeds. One plant may produce up to 17 buds after the first flowerless year. The spiny leaves grow in whorls.

The *girasole* or *Jerusalem* artichoke is not a true artichoke. H. J. C

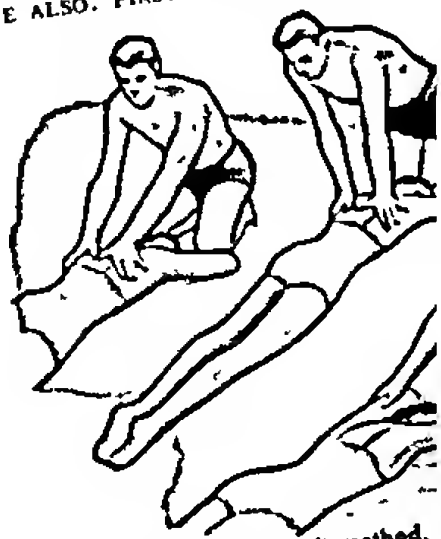
Artificial respiration In animals with lungs, the breathing in of air and the breathing out of air is called *respiration*. In healthy animals and people this is automatic. In cases of drowning, strangling, poisoning by gases or drugs, electric shock, bulbar polio and spinal cord injuries normal respiration may stop. Then artificial respiration, which is the act of forcing air in and out of the lungs by applying external physical pressures, is necessary.

There are many different ways of giving artificial respiration. Mouth to mouth breathing is effective in inflating the lungs and providing oxygen, especially for children. The *Holger-Neilsen Method* is often described as the back-pressure-arm-lift method. It is easy to learn; it can be performed with little fatigue; and, it provides for a great exchange of air in the lungs. Many organizations such as the American Red Cross, the Boy Scouts, the Girl Scouts and the United States Army have adopted it as standard first aid procedure. The Schafer or *Prone-*

when used on patients whose arms ha been injured. Steady, rhythmic pressure applied to the back with alternating pere of release The Sylvester or *Supine Meth* involves only the arms of the patient, should be used when it is impossible to the patient face down or to apply pres to the back

In cases where artificial respiratio necessary over an extended period of as in bulbar polio, certain mechanic vices are used Among these are the LUNG and the rocking bed G

SEE ALSO. FIRST AID, RESPIRATORY S



In Back-pressure Arm-lift method, down, hands under cheeks, face t places hands on back with palm armpit. Rocking slowly forward, creasing pressure Bad air is stopping pressure, rescuer holds drawing them upward until te victim's shoulders. This expand draws good air In Cycle should times a minute

In Mouth-to-mouth method, first cleared by drawing vic ward with him an stomach mouths with hands, air is bro mouth until lungs expand. R mouth and applies slight p victim. Cycle should be re minute

Asbestos is a fibrous mineral used for fireproof materials

Asbestos Asbestos is either of two fibrous silicate minerals. The fibers of *chrysotile* can be woven into fireproof cloth and insulating sheets.

The other type is *amphibole* asbestos. It is used to make acid-resistant materials. Both kinds occur as part of certain igneous rocks abundant in Alabama, Georgia, Quebec, South Africa and the Ural Mountains of Russia.

D. A. B.

SEE ALSO: MINERAL, SERPENTINE

Ascaris (ASS-kuh-riss) Ascaris is a roundworm which is not segmented. It is a PARASITE, which means it lives in another living creature from whom it gets its food and shelter. The ascaris is found in the intestines of man and domesticated animals. They are uninvited guests that set up housekeeping in the intestines, entering the body through the mouth. These worms come from infected beef, pork, fish, vegetables, or water supplies. A doctor can treat a person who has discovered roundworms in the bowel movements. Certain drugs will kill the worms and the eggs.

A human being or other animal can become infested with roundworms by eating food that has been contaminated with the eggs or the adult of the roundworm. The worms will live in the intestinal canal and the eggs will hatch into worms and live, grow, and reproduce. The larvae sometimes pass through the intestinal wall into the venous system and cause lung inflammation. Along with the contents of the bowel, the eggs of these parasites are excreted to be taken up later by man or by other animals for a repetition of the cycle.

When a person has roundworms, there few symptoms unless he has a great of worms. Worms are no disgrace but they need treatment. The most important treatment, however, is prevention. Many thousands of lives have been spared of worms because of proper disposal of sewage and garbage. Careful inspection of cattle and foods, and thorough washing and cooking of vegetables and meats have helped to decrease the number of worm-infested people and animals. J. K. K.

SEE ALSO: NEMATHELMINTHES

Ascorbic acid see Vitamin

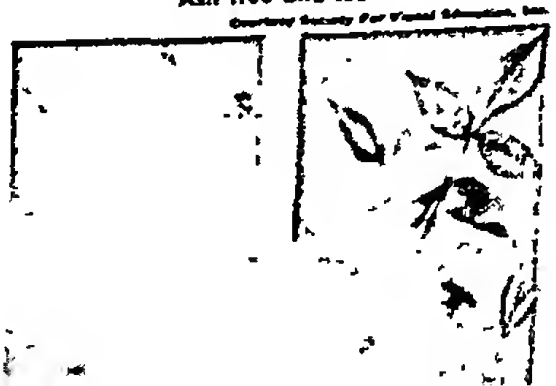
Asexual reproduction see Reproduction, asexual

Ash Ash trees are common trees in yards and parks. There are over 50 different kinds of ash trees, such as red, black, blue, green and white ash. Students can tell one kind from another by studying the leaves. Ash trees belong to the OLIVE family.

Ash wood is widely used because it is strong and hard, yet light weight and flexible. There is ash wood in baseball bats, snowshoes, airplane parts, cars, garden tools, church pews, bowling alleys, bushel baskets, hammer handles, and in many other things that require a hard, tough wood. Ash wood makes good fireplace fuel, and logs of ash will burn while they are still green because the sap in the wood is flammable.

Ash trees are found in all sections of the United States. The most common variety is the white ash which grows to 120 feet. Red ash trees are usually found in wet places, while green ashes may be found on the prairies of the West and on river banks of dry country. The blue ash is prevalent in Tennessee, Kentucky, and the Ohio Valley. Black ashes are found in swamps of New York and the New England states. J. D. B.

Ash tree and leaf



Chicago Natural History Museum

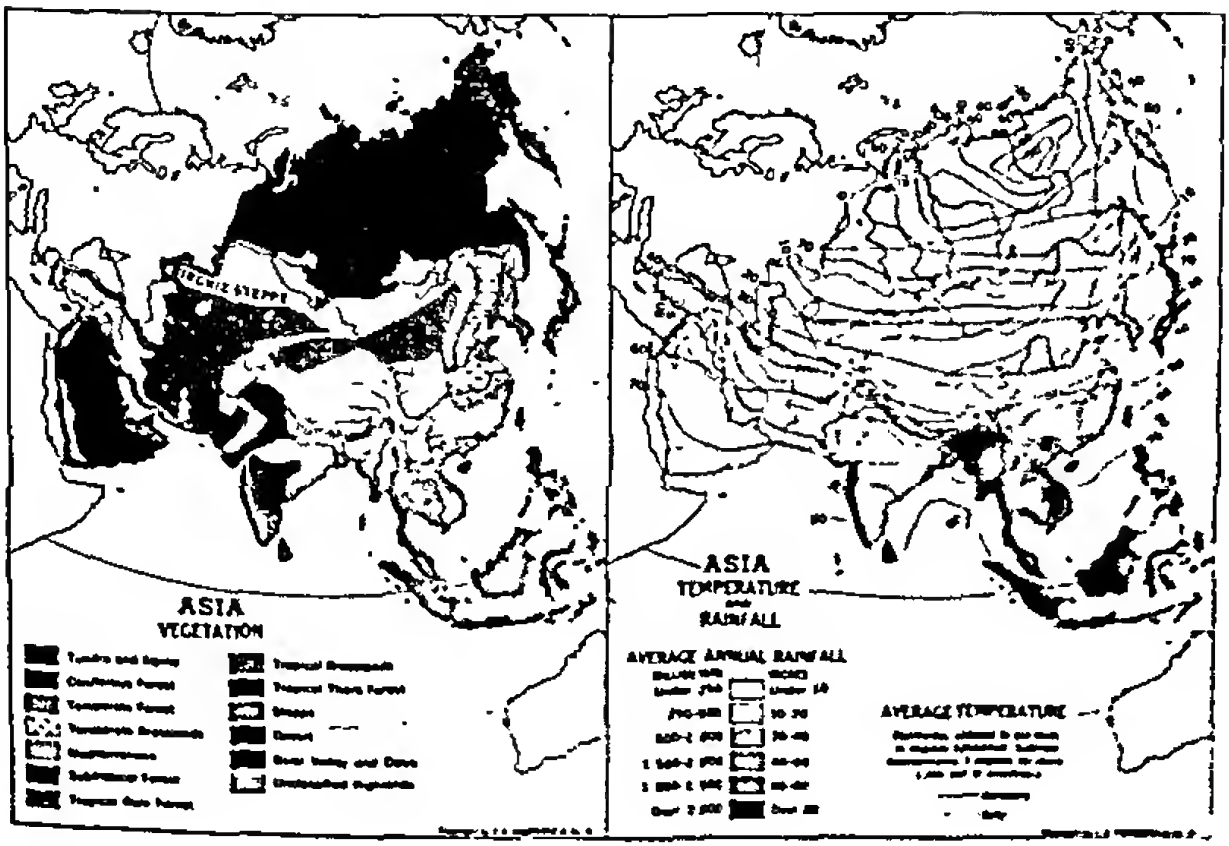
The water buffalo is commonly used for work and riding in Asia

Asia Asia is the largest continent on earth. It covers one-third of the land area of the world. EUROPE, which is counted as a separate continent, is really connected to Asia like a huge peninsula. More than half of the people of the world live in Asia.

Asia is so large that practically every CLIMATE may be found in some part of it. It has the coldest spot in the northern hemisphere at Verkhoyansk —colder than the North Pole. In southwestern Asia the desert temperatures may be as high as anywhere on Earth.

About half of Asia consists of bleak plateaus and high mountains. Mount Everest is over 29,000 feet high—the highest mountain on earth.

Asia faces three oceans—on the north, the Arctic; on the east, the Pacific; and on the south, the Indian Ocean. On the Pacific side, where there are branching land formations and islands, the arms of the ocean are designated as seas. Among these are the South China Sea, the Sea of Japan, and the Sea of Okhotsk. Asia has nearly 50,000 miles of coast line, much of it making good harbors.



The longest poisonous snake known is the cobra of southeastern Asia

Courtesy Society for Visual Education, Inc.

Chicago Natural History Museum

The sloth bear of India

Chicago Natural History Museum

The takin of China is related to the goats

Chicago Natural History Museum

The seladang is a wild buffalo found in the forests of Indo-China

LAND FORMS

The continent of Asia extends from the equator to 80° north LATITUDE (N. Lat.) although some of the Asian islands extend to 10° S. Lat. In LONGITUDE, Asia extends from about 27° E. to 170° W. The area of Asia is about 18,000,000 square miles.

The mountain chains of central Asia are tremendous. From this central point of the great Pamirs, the Hindu Kush range extends westward through Afghanistan. Elevations are as great as 20,000 feet.

Eastward from the Pamirs, the impressive mountain system branches in several directions. The Karakoram arches north and the Himalayas southward. There is also a shorter range of the Himalayas lying east and west. Many mountain peaks are nearly as high as Mt. Everest, and even the passes through these mountains are at elevations of 14,000 feet or more. Mountains branch off into Southeastern Asia and China. Northeastward the mountains form a boundary of Outer Mongolia and extend into Siberia.

The Tibetan plateau lies at an elevation of about 16,000 feet, but the Mongolian plateau is not more than 5,000 feet high. Plateaus are numerous over the continent. Asia has seven major plateaus, including the Dekkan in India, the Anatolian in Turkey, the Arabian, and the Iranian. Hill country is often associated with plateau regions. South China is largely a hilly region, and India, as well as Southwestern Asia, contains many foothills.

CLIMATE

The climate and rainfall of Asia present great contrasts. The Malay Peninsula has a *rainy tropical* climate so constant that the average temperature from month to month varies only 1° F. At the other extreme, land along the Arctic Ocean has subpolar climate with only a short summer season. *Rainfall* is ten inches or less, similar to the dry desert regions farther south.

North of the rainy tropics are found the *monsoon tropics* which include most of India, Indochina, Burma, and Thailand. This climate has a rainy season varying from five to eight months, followed by a dry season the rest of the year. During the rainy reason the average rainfall is 50 inches, but in the hill slopes of Assam (eastern India) the average is over 400.

The rainy season starts in the spring when steady moisture-laden winds blow from the


ATLANTIC
OCEAN
GREENLAND
ICELAND
NORTH SEA
NORWAY
SWEDEN
FINLAND
BALTIC SEA
Moscow
UNION OF SOVIET SOCIALIST REPUBLICS
RUSSIA
Siberia
ARCTIC OCEAN
KARA SEA
BERING SEA
Bering Strait
SEA OF OKHOTSK
BLACK SEA
CASPIAN SEA
Aral Sea
Lake Balkhash
MONGOLIA
Gobi Desert
ALTAI MOUNTAINS
Urumchi
Sinkiang
CHINA
KUNLUN MOUNTAINS
Tibet
Peking
Tokyo
Shanghai
EAST CHINA SEA
YELLOW SEA
SAUDI ARABIA
Mecca
ADEN PROTECTORATE
Gulf of Aden
Karachi
Tropic of Cancer
New Delhi
Calcutta
Bombay
INDIA
ARABIAN SEA
BAY OF BENGAL
Madras
CEYLON
Colombo
Rangoon
SOUTH CHINA SEA
PACIFIC OCEAN
Hainan
Luzon
REPUBLIC OF THE PHILIPPINES
CELEBES SEA
JAVA SEA
BANDA SEA
Djakarta
INDIAN OCEAN
AUSTRALIA
Tropic of Capricorn
Map of ASIA
Capitals of Countries
Cities
Boundaries of Countries
Other Boundaries
Mountain Peaks
Canals

The ibex is a wild goat of the Himalayas

Marco Polo's sheep is largest of sheep family

Chicago Natural History Museum

The rare Indian rhinoceros of the Assam plains

Indian Ocean over the land. Differences in air pressure cause this constant movement. In the dry season, cold air over the continent exerts high pressure compared to the air over the Indian Ocean. For months the dry winds blow land to water

Most of China has a humid *subtropical* climate similar to that of southeastern United States. *Rainfall is adequate and sufficient to* support a forest cover. Southwestern Asia and much of the interior of the continent are very dry. Here the *tropical* deserts of Arabia and the Thar in Northwest India are found. One desert, the Gobi of Mongolia, is too far from the equator to be a tropical desert. North of the Himalaya Mountains, the wind directions are generally west to east. The air is dry because it has blown over thousands of miles of land without the influence of bodies of water. The climate across Siberia is a *continental* type of climate with sufficient rain for a heavy forest cover known as the *Taiga*. There are three to five frost-free months during a year.

RIVERS AND DRAINAGE

Asia has many rivers. Those in southern and eastern Asia are very important to the people who live along their floodplains. The fertile plains where water is available for irrigation provide food for millions of people. The important rivers of India and Pakistan are the Ganges, the Bramaputra, and the Indus. The Bramaputra flows into the Ganges as it empties into the Bay of Bengal. In Iraq the Tigris and Euphrates rivers flow into the Persian Gulf. These rivers provide oases in a very dry region. In North China, the Hwang Ho, sometimes called the Yellow River, has built up a vast floodplain. This river actually lies above the level of the surrounding land. It is held in place by both natural and man-made levees. When great floods occurred in the past, many lives were lost from drowning or from the famines which followed. The Yangtze and the Si are two important drainage systems in China. The Irrawaddy and Mekong rivers are found in southeastern Asia.

In the north, there are many rivers flowing toward the Arctic Ocean. Three of the more important ones are the Lena, the Ob, and the Yensei. In one sense these rivers seem to thaw. This makes swampy and flooded colder regions, and their mouths are the last to thaw. This makes swampy and flooded conditions in the short summer season.

In central Asia there are many rivers which have no outlet to the sea. This vast region lacks a proper natural drainage system. As a result, these rivers flow into lakes and inland seas which are salty, such as the Aral and the Caspian seas.

PLANTS AND ANIMALS

Asia has a varied plant and animal life. In Siberia the plant life varies from TUNDRA in the north to steppes or prairieland in the central region and evergreen forests in the southeast. In the west on the slopes of the Ural Mountains, forests of valuable HARDWOODS and conifers grow. The animal life in these varied habitats include the ermine, sable, bear, wolf, fox, marten, lynx, squirrel, skunk, otter, and hare.

Southwest Asia presents a contrast

Chicago Natural History Museum

The giant panda of western China and Tibet was considered to be a myth until 100 years ago

of dry lowlands and forested mountains. These forests are made up of oak, pine, fir, cypress, and cedars of Lebanon. In the valleys FRUIT TREES like orange, apricot, cherry, plum and fig grow abundantly, as do grape vineyards and dates. Wild animals are still abundant in the mountains and include wolf, brown bear, leopard, tiger, mountain sheep, and deer. In the valleys and upland meadows sheep, goats and camels are herded. Two varieties are unique—the angora (long-haired) goat of Turkey and the fat-tailed sheep of Afghanistan.

The high mountains of central Asia have great evergreen forests and animal life which includes mountain sheep and goats, musk deer, and the yak.

The monsoon regions of India and southeast Asia have three principal types of vegetation—savanna, tropical jungle and mountain forests. The commercial trees include ebony, teak, sandalwood and bamboo—a tree-like grass. Jute, for making burlap bags, and spices, like pepper, tumeric, ginger and anise are gathered from wild plants or are cultivated. Cinnamon bark, rubber, and coconuts are harvested from native and cultivated trees.

The wild animals of India, Burma, and southeast Asia include the tiger, leopard, elephant, monkey, one-horn rhinoceros, honey bear, water buffalo and wild dogs. The elephant and water buffalo are domesticated for heavy work.

The plant and animal life of China has all the variations of Asia as a whole, from the cold forested mountains of Manchuria to the tropical jungles of southeast Asia, and from the monsoon east to the deserts and mountains of the west.

NATURAL RESOURCES

The lowland plains of North China (Yellow Plain) and the Yangtze farther south have rich fertile alluvial soil. The population pressure on the land here is very great. The soil of North China is largely fine, windblown soil known as *loess*. Deposits may reach thicknesses of hundreds of feet. The Yellow River carries large quantities of this fine silt.

The continent of Asia does not have the great natural resources found on some other continents, especially the basic minerals for industrialization, with the exception of oil. The Middle East may contain the greatest petroleum resources so far known in the world. Coal is found in reasonable abundance, but iron ore deposits are not great. Rubber, tin, timber, gems, manganese, and mica are a few of the many things the world seeks from Asia. D. H. J.

SEE ALSO: EARTH, EUROPE, NATURAL RESOURCES

Asp see Snakes

Courtesy Society For Visual Education, Inc.

Asparagus

Asparagus (as-PAIR-uh-gus) Asparagus is a green vegetable. People have enjoyed it for over 2,000 years as a special treat in the springtime.

Asparagus is a perennial. The spears (young stems) are harvested each year. The plants lack true leaves, having scales instead. The tiny flowers are yellow-green. Plants produce staminate and pistillate flowers. When the female flower is fertilized, it develops into a round, red berry.

The roots of asparagus plants grown from seed are set in a ridge of soil. As the asparagus grows, the trenches are filled. A good asparagus bed will yield for ten or 15 years or longer.

After the stems are six inches or longer, they are cut two inches below the ground. Three to five stalks on each root are left to grow and develop into stems and leaves.

P. G. B.

Aspen Aspen is the name of several species of poplar tree, including the trembling aspen and large-toothed aspen. It is a small tree with yellowish-green bark and finely toothed leaves attached to the stalk in such a way that they flutter easily. The trembling aspen is the most widely distributed tree in North America.

SEE: ANGIOSPERM, POPLAR

Large-toothed aspen

Asphalt Asphalt is one of the most useful materials known. It is used in roads, runways, batteries, roof coverings and automobile undercoatings. As a liner in irrigation ditches, it prevents loss of water by seepage. Playgrounds and parking lots are often covered with it and buildings are made soundproof and fire resistant with it.

Asphalt was used in ancient times to make ships and reservoirs watertight. Stone walls were held together with it and roads were made smooth and durable. Asphalt, commonly called *pitch*, is organic in origin. It is found in pools or lakes which were formed by the

Asphalt is a common substance for road surfaces

remains of ancient plants and animals. Some of the best deposits in the Western Hemisphere are in Trinidad and Venezuela. It is also found in scattered areas of Europe and the Far East.

Useful supplies of asphalt are found in some porous rock formations, but most of the asphalt used today is obtained synthetically as the thick residue of processed PETROLEUM. In its natural state or its processed form, it is black or dark brown in color. It may flow like thick syrup or be as hard as a rock.

Because of its many uses, asphalt has great commercial value. It can withstand great variations in heat and is quite flexible. It mixes well with crushed rock or other construction materials, and it can support great stresses without breaking.

D. E. Z.

Asphyxia (ass-FIX-ee-uh) Asphyxia is a condition in which the supply of oxygen in the body is too low and the supply of carbon dioxide is too great. For life, it is necessary that the BLOOD continuously take a fresh supply of oxygen to the cells and receive carbon

dioxide from them as waste materials. In CARBON MONOXIDE poisoning, caused by smoke, automobile exhaust, or gas fumes, there is breathing interference with this process. Carbon monoxide has a much greater attraction for the hemoglobin of the blood than does oxygen. If there is carbon monoxide in the lungs, the hemoglobin reacts with it rather than with oxygen. This lack of oxygen may result in death of the cells.

In cyanide poisoning, the blood carries its usual oxygen supply to the cells but the enzymes of the cells are affected so as to make the exchange of oxygen and carbon dioxide impossible.

Mountain climbers often suffer with asphyxia. At very high altitudes the air has a low oxygen content.

In such accidents as drownings, chokings, hangings or any other blockage of the air passages, there is interference in the process of inhalation and expiration.

Newborn babies may also experience asphyxia when their lungs fail to expand fully at birth. G. A. D.

SEE ALSO: RESPIRATORY SYSTEM

Asphyxiation see Asphyxia, First aid

Aspirin Aspirin is a white crystalline compound. It is the ester of salicylic acid and ACETIC ACID—*acetylsalicylic acid*. Proper dosage tends to reduce the body temperature of a person with a fever. It relieves certain types of joint and muscular pains and is commonly used for colds and fever. Aspirin (in large dosage) has been effective in treating acute rheumatic fever.

The name aspirin is derived from the early name for salicylic acid which was known as *Acidum Spiricum*.

Acetylsalicylic acid was prepared first by Gerhardt in 1853 and then by Kraut in 1869, by the action of acetyl chloride upon sodium salicylate (a salt of salicylic acid) A United States patent was issued to Hoffman in 1900 for its preparation by the actic of acetic anhydride on salicylic acid Th formula was considered to have differe chemical and medical properties from ar American fever drug previously patented was at this time that aspirin was introduce for commercial use. W. J. I

SEE ALSO: DRUGS, ESTER

Ass see Donkey

Assaying (uh-SAY-ing) Assaying i any process used to find out how muc and what kinds of metals are in a roc sample or an unknown alloy. The mai methods of assaying are the *wet pr cess* and the *fire process*.

In wet assaying, the unknown sample mixed with another chemical in solution. Th identifiable products resulting are separate and weighed.

In the fire or dry process, the sample ma be first crushed and the pure substances sifte out. Or it may be roasted and the product collected and measured. J. D. I

SEE ALSO: METAL, MINERAL

Assimilation The body must hav food to remain alive and healthy. Bu many foods cannot be used in the form in which they are taken into the body They must first be changed by *diges tion* into simple units. These units ca then be used as building blocks fo larger, more complicated substance needed by the body in its *protoplasm* Assimilation is the incorporation o the end products of digestion int living protoplasm within the cells o the body.

Foods belong to three basic groups: car bohydrates, fats and proteins. For assimila tion into living protoplasm, carbohydrate must be changed into simple SUGARS; fat into FATTY ACIDS and glycerol; proteins int AMINO ACIDS. These basic building block can then be used as needed to put togethe the protoplasm required by the body. Water, minerals, and enzymes are also necessary in the process of assimilation. G. A. D.

SEE ALSO: ABSORPTION, DIGESTIVE SYSTEM METABOLISM

Astatine (ASS-ta-teen) Astatine is a radioactive ELEMENT whose chemical symbol is At. In some respects it is similar to IODINE and has been found in the thyroid glands of GUINEA PIGS.

Astatine is difficult to find in nature because it is unstable and radioactive. Unless it combines with a long-lived substance, it decomposes quickly. The short-lived radioactive forms then result.

Astatine is element number 85. The mass number of its most stable isotope is 210. It has twenty ISOTOPES, all prepared by nuclear reactions. The most important, At^{211}, was first made in 1940 by bombarding bismuth with alpha particles. *Astatine* means *unstable.* The element is known only through radioactivity. D. L. D.

SEE ALSO: ATOM, ELEMENTS, RADIOACTIVITY

Aster *Aster* means *star*, and the flower head of the aster plant looks like one. It is a composite plant and so has not one big flower but many tiny flowers in a cluster. The flower head may measure one-half inch to six inches across. Asters bloom in the fall.

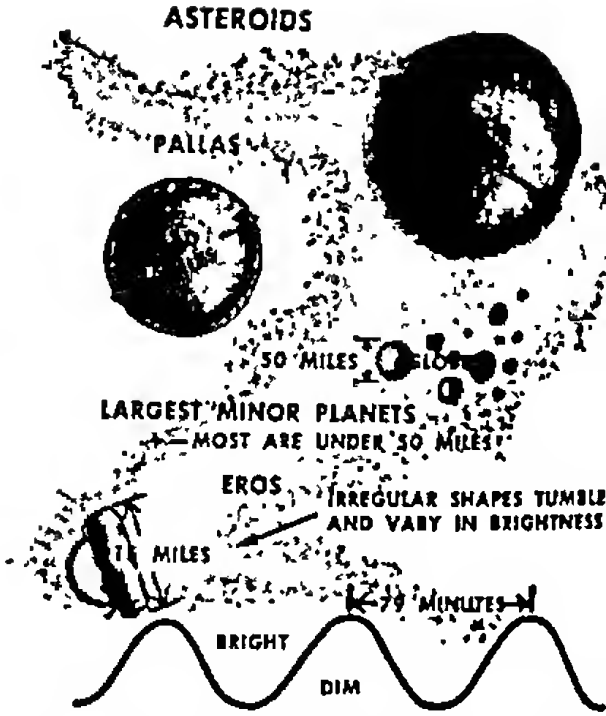
The *annual* or *China aster* was once a tiny flower but the modern hybrid species are large and showy. They come in every color except yellow. The plant grows one to three feet tall with a thin stem, many leaves near the ground, and a giant flower head.

The *Stokes aster* is a wild perennial of southern states. The long leaves grow from a hairy stem. The blossoms are purple to blue.

The perennial *hardy asters* were developed by crossing the Italian, New York and New England varieties. They grow 10 to 70 inches high. The *yellow aster* is a perennial of eastern states. It is not grown widely but will thrive in poor soil. H. J. C.

SEE ALSO: COMPOSITE FLOWER

Aster



Asteroid (ASS-ter-royd) Asteroid means "like a star." Planetoid means "like a planet." Asteroids, also called planetoids, are heavenly bodies that look something like stars. Actually, they are minor PLANETS. They are much, much smaller than the regular planets of the SOLAR SYSTEM. Some of them are only one mile in diameter.

There is a wide gap of space between the orbits of Mars and Jupiter. At one time astronomers thought that there must be a planet there that had not been discovered. When they searched the skies with their telescopes and cameras, they found not one planet but hundreds of minor planets. Since then asteroids have been discovered scattered between the orbits of Mercury and Saturn, but the majority of them are between Mars and Jupiter. Some astronomers suppose that these small planets might be fragments of a larger planet that used to orbit between Mars and Jupiter. Others think that some of them might have been satellites of Jupiter at one time. Many believe that they have always been exactly as they are now, merely small lumps of rock that orbit around the sun, chiefly between Mars and Jupiter.

The largest asteroid known is *Ceres.* It has a diameter of about 490 miles. *Vesta* is the brightest one and is the only one that can be seen without a telescope. C. L. E.

SEE ALSO: ORBIT, STAR

Asthma A person who has run and played so hard that he is out of breath and has to lean against a fence or flop down on the ground until he can catch his breath is going through what a person with asthma goes through. Sometimes for long periods of time the person with asthma cannot breathe normally. There is a big difference between a normal person's being short-winded after exercise and an asthmatic's being short-winded. The asthmatic is breathless because he is sick.

The part of the body involved in an attack of asthma is the LUNGS. Within the chest are two lungs that fill with air whenever one takes a breath. Leading to the lungs from the throat is the *trachea* or windpipe. The trachea branches out to each lung, both to the right and to the left, through smaller tubes called *bronchial tubes*.

During an attack of asthma, the bronchial tubes swell and the air passageway through the tubes becomes so small that air is almost cut off from the lungs. An attack of asthma may come when the asthmatic person breathes dust from plants (POLLEN), household dust, animal fur, feathers, flour, or face powder. The same thing may happen when he eats certain foods such as milk, eggs, or wheat. When these particles and foods are taken into the body, they may cause an allergic reaction with the release of histamine. Histamine stimulates the bronchial muscles and glands to produce asthma.

Nervousness and emotional disturbance sometimes account for an attack of asthma. If a person is very tired from overwork in the house, on the job, or at play, and he then experiences a great disappointment, learns of the death of a loved one, or becomes very angry, he may develop an asthmatic attack.

An asthmatic attack is easily recognized. The victim's breathing-out is long and "wheezy" while his breathing-in is labored and difficult. He sits with his elbows on his knees and his head down in order to get help from every muscle of his back and shoulders in his struggle for air. Attacks may last for days or even weeks. Activity, breathing cold air, dust or fumes, tend to worsen the attack. The patient may have to sleep sitting up, catching cat naps between periods of distress. He will probably awaken several times during the night to wheeze and cough until relief comes from some form of medication.

Many medicines bring relief to the asthmatic patient. ADRENALIN, ephedrine and ATROPINE relax the bronchial constriction and stop the spasm. Antihistamines are used to counteract the histamines released after an allergic reaction. CORTISONE removes the symptoms of stress and reduces the inflammation of the bronchial tissues. Aminophylline or even steam inhalations clear the bronchial tubes of fluid.

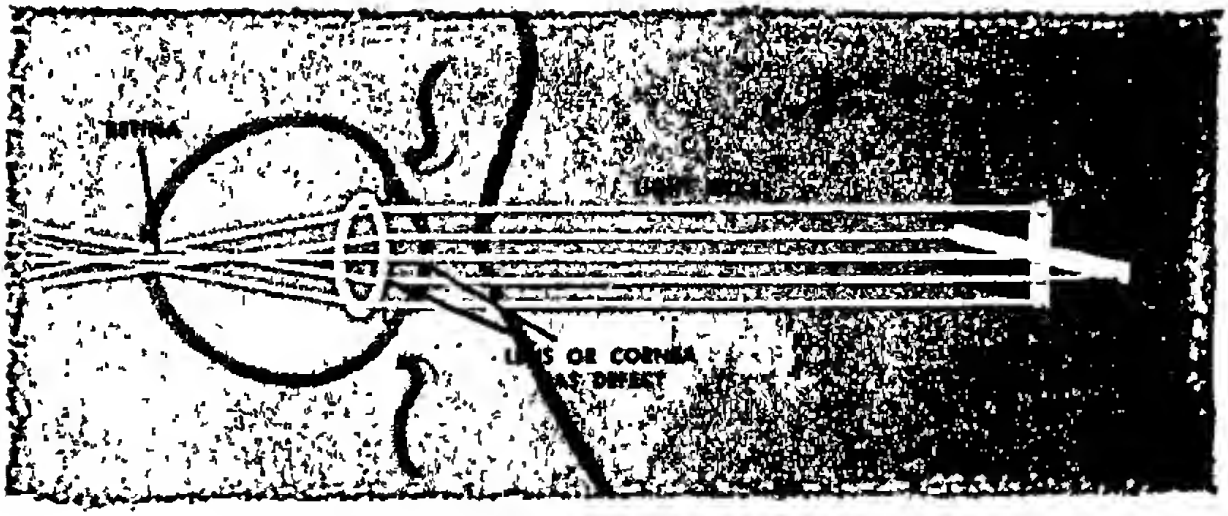
The best preventive measure is to avoid allergic reactions by removing the substances which cause asthma. Respiratory infections aggravate asthmatic conditions Mild climate, dust-free surroundings, rest, and peace of mind are helpful to the person who suffers from asthma. D. C. H.

SEE ALSO: ALLERGY, RESPIRATORY SYSTEM

Astigmatism (uh-STIGG-muh-tizz-uhm) An astigmatism is a visual defect. A person with an astigmatism is unable to see objects clearly. Images appear blurred, fuzzy and often elongated. To see images clearly the rays of light coming into the eye must focus directly on the retina. In astigmatism rays of light from an object pass through the structures of the EYE and focus in different planes. Some focus in front of the retina; some focus on the retina; some focus behind the retina. This difficulty in focusing is caused by defects in the curvature of the lens or cornea.

In some cases of astigmatism defects in curvature are caused by disease or injury This form of astigmatism is rare and can be corrected by treating the disease or the injury which causes it.

The most common form of astigmatism is present from birth and is due to an abnormal structure of the eye. Astigmatism can be corrected through lenses (eyeglasses) which are ground so as to redirect the light rays which are out of focus.



In an astigmatic eye, light rays do not focus directly on the retina

Persons suffering from astigmatism may experience other difficulties beside poor vision. Some of the other symptoms are headaches, drowsiness (especially when the eyes are used for a long period of time), and severe pain in the eyes. G. A. D.

SEE ALSO: FARSIGHTEDNESS, NEARSIGHTEDNESS, OPTOMETRY

Astragalus The astragalus is a BONE of the foot called the *ankle bone* in man.

SEE: SKELETON

Astringent (uh-STRIN-jent) An astringent is a substance that draws together living tissues. It is used in medicine as a drug to cause contracting or binding of wounds and to stop the escape of fluids from living cells.

Astringents may act to stop bleeding from wounds by constricting the capillary blood vessels. They may also prevent DIARRHEA or shrink the nasal or urinary passages when INFLAMMATION swells the mucous membranes. The discharges are stopped and the tissues can heal more easily.

Some substances that act as astringents are alum, tannin, silver nitrate, zinc sulfate, and dilute mineral acids. B. B. G.

Astrolabe An astrolabe is an instrument sailors used to use to measure altitude of heavenly bodies. From this they figured LATITUDE and time of day.

SEE: ASTRONOMY, NAVIGATION

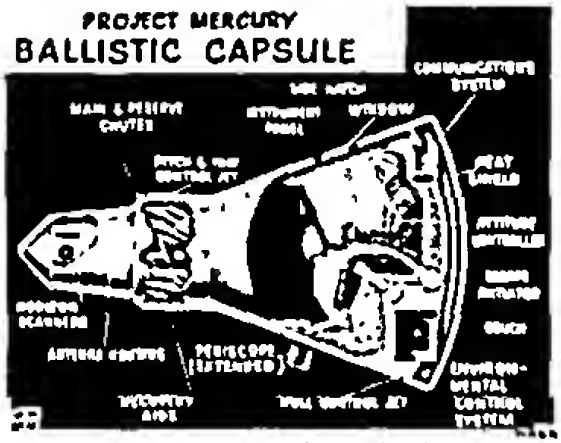
Astrology (ah-STRAHL-oh-jee) Almost from the beginning of history men have believed that stars and constellations influence events on Earth. They felt that those who studied the stars could predict coming events. This study was called *astrology*.

In early times, astrologers knew more about the heavens than anyone else. Later, scientists began to separate true facts from superstitions. This study was called *astronomy*. Astrology has now been replaced by scientific astronomy and is not now considered to be a real science.

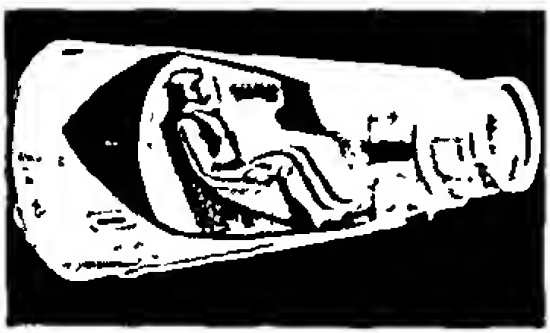
Astrology began in the ancient Biblical lands of the Near East. It developed there and in many other early lands, especially in India. The ability of ancient astrologers with limited knowledge and crude instruments was truly remarkable. They gave man his first real knowledge of the universe. They discovered many important facts about the space beyond Earth, how to predict eclipses, movement of stars, planets and groups of stars. But it was difficult for them to distinguish true facts from mere beliefs. Even today many people believe their lives are influenced by the stars and planets.

Many newspapers carry predictions called *horoscopes*, based on various birthdates and the signs of the zodiac under which they fall. However, there is little scientific basis for the predictions. J. A. C.

SEE ALSO: SUPERSTITIONS, ZODIAC

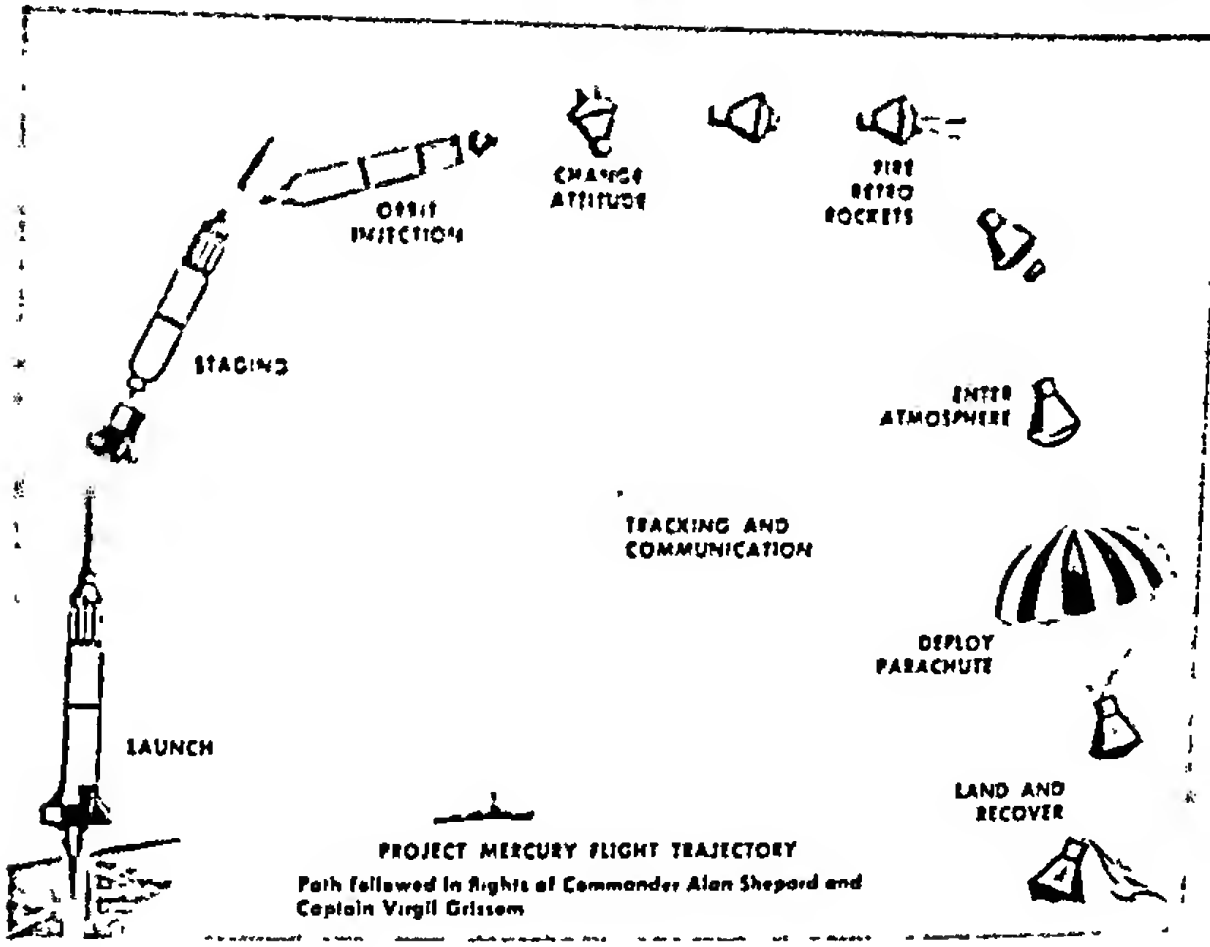


Astronaut (ASS-troh-not) An astronaut is a person who travels outside the earth's atmosphere in space. His vehicle is called a SPACE SHIP if it is large or a space *capsule* if it is small. The smallest space capsule which probably will ever be built is the *Mercury* space capsule. It was developed to carry the first American astronaut into an orbit around the earth.



The manned capsule used in American Project Mercury (shown at top of page) is probably the smallest manned space vehicle that will ever be made. Astronauts Shepard, Grissom, Glenn, Carpenter, Schirra and Cooper have traveled in it. The capsule in which the Russian cosmonauts first rode (above) is somewhat larger. It was constructed so that it could be controlled almost completely from Earth. The American astronauts were able to control a number of capsule movements from within the vehicle

Rocket, carrying space capsule, at launching



The capsule offers the astronaut hardly more space than the cockpit of a jet fighter offers to the pilot. The astronaut sits in a couch-type chair which is especially molded to fit his body shape, clad in a space suit. This chair is called a *contour* chair. Its purpose is to offer the greatest possible comfort to the astronaut who not only must spend many hours in it once he is on his way, but who also must tolerate very unusual conditions during the flight.

At first, while the rocket ascends to carry him into orbit, the push of powerful ROCKET ENGINES accelerates the astronaut and his capsule faster than any other vehicle can, even a race car or a jet plane. This acceleration presses the astronaut into his contour chair with a strong force, as if his weight were greater than normal. Suppose the astronaut in his space suit weighs 200 pounds. Then, at the moment the Atlas rocket, which carries the Mercury capsule, lifts off the launching pad, he would "weigh" about 260 pounds, gaining 60 pounds in less than a second. Then, as the rocket flies faster and faster, his "weight" keeps going up, until he "weighs" around 1,400 pounds!

After he has reached orbital altitude, the rocket engines shut off and now his "weight" drops to zero. He is weightless, since a body which is in orbit is in a condition of *free fall*. When jumping off a diving board, one experiences weightlessness until hitting the water surface. The time is very short (a few seconds at the most) so that people often do not even become aware of it unless they pay special attention. When jumping off a diving board, one falls essentially straight downward. An astronaut in orbit does not fall straight downward, but rather falls in a wide arc, so wide, in fact, that he keeps missing the earth's surface which is also curved like an arc, since the earth is almost a sphere; but he falls just the same. He falls for hours and hours, falling once around the earth in about 1½ hours. As long as he

continues this, he will be weightless. In order to return, he slows his capsule down somewhat by means of *retro rockets*. Immediately his arc of fall becomes shorter. He loses altitude. His capsule enters the atmosphere.

The capsule has approximately the shape of a television tube. The blunt side is turned forward into the air stream, causing considerable air drag which slows the capsule down further, causing, in turn, the flight path to bend downward with increasing steepness While this happens, the astronaut's "weight" increases again, this time due to *deceleration*, rather than acceleration as during the ascent. During the descent his peak "weight" will be "only" about 1000 pounds, if everything goes all right. If he enters along a too steep path, due to an error in the flight path, his "weight" may reach 2000 pounds or more. He is prepared to stand a "weight" of more than 3000 pounds! The entire descent is over in about 10 minutes He will have to tolerate his peak "weight" for only a fraction of a minute. Once slowed down to subsonic (below the speed of sound) velocity, the capsule sinks gently to the ground on a parachute.

The *Mercury* capsule development began in 1959. A chimpanzee named Ham was first to ride into space in this craft. He was launched in February, 1961, with a *Redstone* rocket into a trajectory (path) 156.5 miles high and 414 miles downrange.

ALAN SHEPHARD was the first of America's seven astronauts to go into space when a *Redstone* carried him aloft on May 5, 1961, from Cape Canaveral, Florida. He reached an altitude of 115 miles in a suborbital flight of 302 miles downrange. He checked out the capsule's controls and proved that man could withstand the rigor of launch and reentry without ill effects. A similar flight was completed on July 21st by Captain Virgil I. Grissom which paved the way for the first U.S manned orbital flight by John H. Glenn, Jr. On February 20, 1962, Colonel Glenn, in his capsule, *Friendship 7*, was launched by an *Atlas* booster for a flight three times around the world. He successfully encountered the forces of flight, performed control tasks, made scientific observations and reentered through the earth's atmosphere for a safe landing.

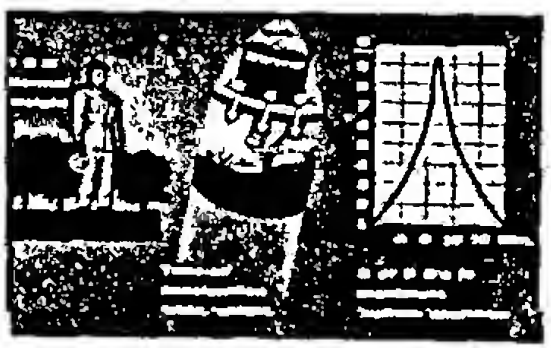
Astronaut M. Scott Carpenter completed an almost duplicate journey on May 24, 1962, followed by a six-orbit flight on October 3, 1962, with Walter M. Schirra in the *Mercury* capsule.

The next major effort to determine man's capabilities in a space environment came on May 15-16, 1963. Major L Gordon Cooper concluded the *Project Mercury* flight series with a 22-orbit, 546,185-mile flight that lasted 34 hours, 20½ minutes. The launch, insertion into orbit and landing of *Faith 7* were nearly perfect. Equally successful were the various experiments, aeromedical studies and spacecraft control. The way was now paved for the United States' next step in mastering space, the *Gemini Program*.

An additional group of nine astronauts were selected by NASA officials in September, 1962 Today, the complete 16-man flight team is engaged in preparations for the first *Gemini* flight. This capsule will carry two men for prolonged orbital flights of as much as two weeks. K. A. E.

SEE ALSO: ASTRONAUTICS, COSMONAUT, SPACE MEDICINE, SPACE TRAVEL

(The rapid developments in both the United States and the Soviet Union prevent a completely up-to-date reporting of astronauts in space technology. Further information will be available in supplementary volumes of this encyclopedia.)



A manned space vehicle must protect the astronaut from pressure and heat

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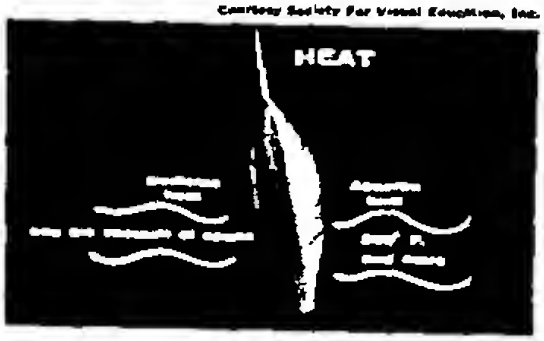
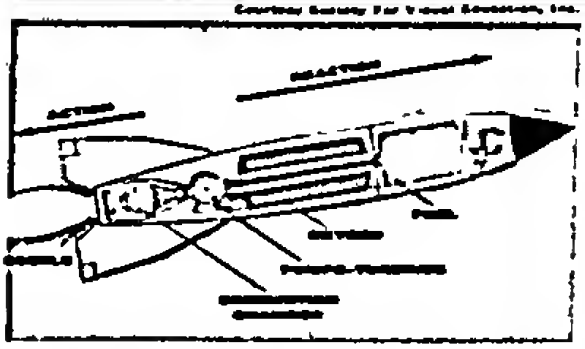
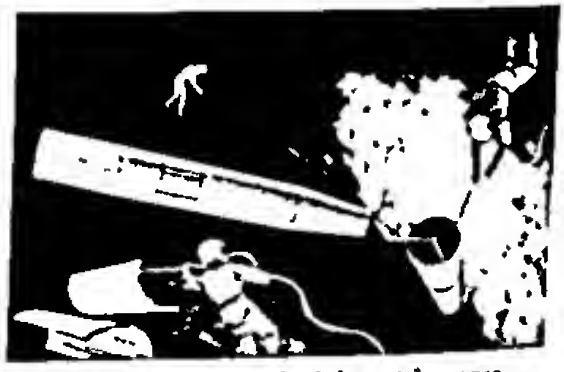


For centuries the idea of a space ship arriving on the moon has been only a dream. Modern science is rapidly turning space travel into an exciting reality



Rocket components compensate for the lack of air in space



Stations may be built right out in space

Astronautics (ass-troh-NAWT-ticks) Astronautics is the science and technology of space travel. It is a blend of almost all scientific and technological fields known to man. These sciences range from astronomy to zoology. Almost everything from aerodynamics to sanitary engineering is a part of astronautics.

Therefore, astronautics is at the height of modern civilization, the most concentrated application of man's capabilities achieved so far in human history. This is understandable if one considers that upon leaving the earth, a space vehicle, whether manned or unmanned, leaves behind everything that might support its functioning. Man and machine are entirely on their own, a tiny world in the vast cosmos which surrounds them. Nothing out in space supports life. In fact, everything threatens its very existence. The conditions, so far as they are known, are equally hostile to life, or at least to earthly forms of life, on all other bodies of the SOLAR SYSTEM, be it the MOON, other planets or their moons.

In this fact lies the main difference between the endeavors of modern astronautical pioneers and the earlier European discoverers who sailed around the globe. They found mostly wilderness, but at least the nature around them was fundamentally the same as in Europe. They had air to breathe, water to drink, wild game or vegetables to eat, a blue sky, clouds, moderate sunshine and a limited range of temperatures. There is nothing at all on the moon that could be used by man for survival.

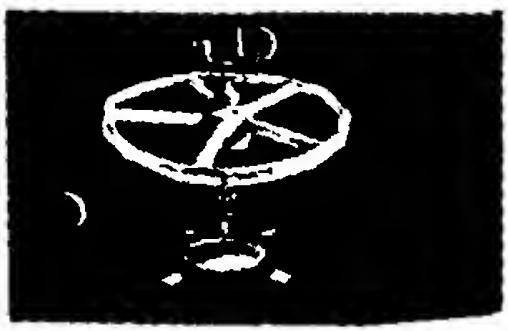
CONDITIONS ON OTHER PLANETS

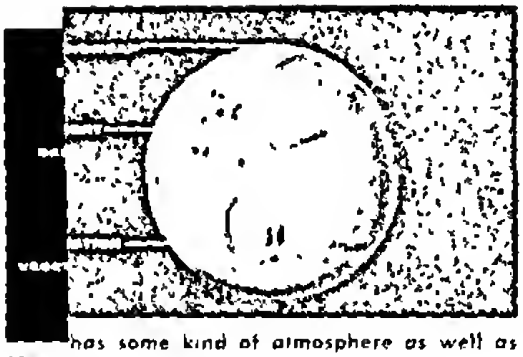
The atmospheres of other planets are without exception poisonous to man, the atmospheric temperatures and surface temperatures are much higher or lower than on Earth. The extremes are tremendous. On planet MERCURY, nearest the sun, lead would melt on the surface. On PLUTO, the most distant planet known, air would be frozen solid. Compared to them, VENUS and MARS, neighboring planets inside and outside the earth's orbit appear hospitable, although even there man or beast would die quickly outside the protective shell of the space ship, a space suit or a specially constructed air shelter.

Nevertheless, the surfaces even of very in-

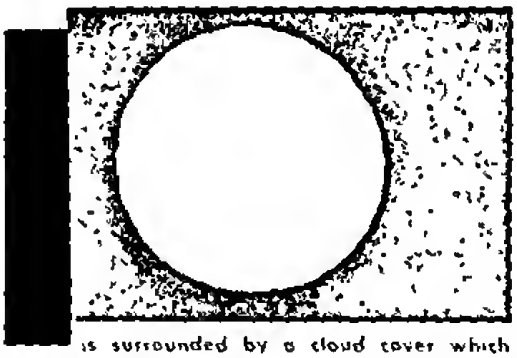
Courtesy Society For Visual Education, Inc.

A space station is a manned satellite which will be capable of becoming a "laboratory in the sky." It could be used for research, military and weather observation of Earth and, perhaps most important, as a base for exploring space travelers

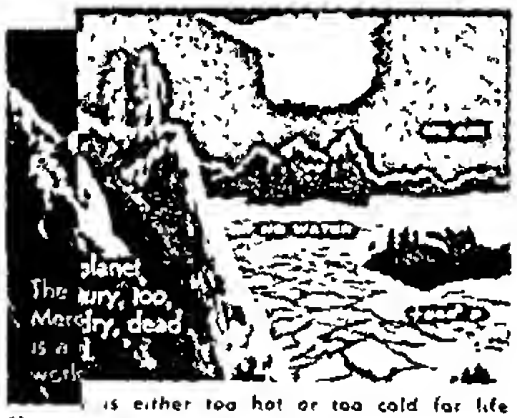




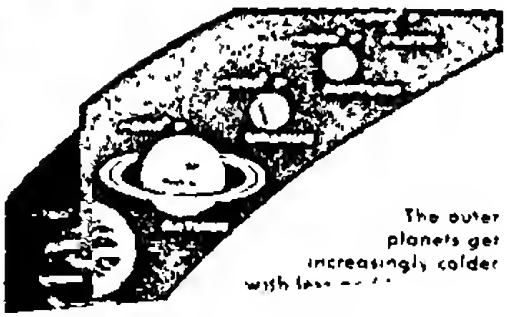
has some kind of atmosphere as well as
Mars visible features such as snow which indi
some not life may be possible there
cate it



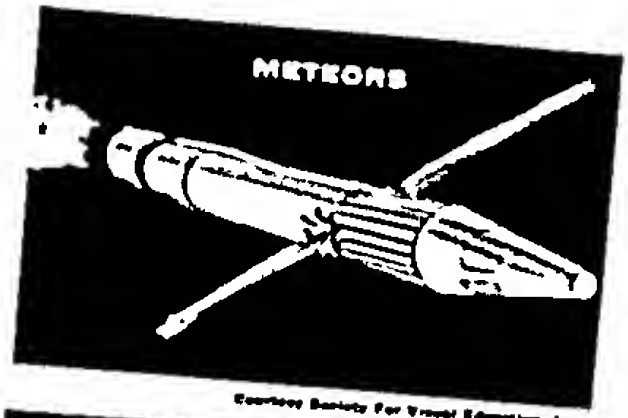
is surrounded by a cloud cover which
Venus is accurate pictures of the surface of the
proven There is no evidence of life
planet.



is either too hot or too cold for life
Mercury



The outer
planets get
increasingly colder



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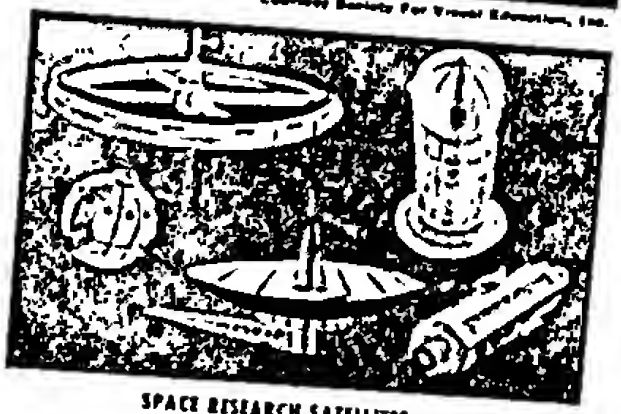


Large meteors may be dangerous to s
space ships (upper left)

MOON PROBES

Vehicle	Description	W
Ranger	Rough landed instrumented capsule on the moon.	
Surveyor	Soft landed spacecraft on the moon. Has provisions to drill into the lunar soil and investigate consistency, composition and temperature of lunar soil.	fe ab lb. mo
Moon Satellite	Injected into a satellite orbit around the moon. To conduct detailed photographic mapping of the lunar surface.	1000
Prospector	Soft landed spacecraft capable of moving around on the moon's surface, remote controlled from the earth	1500-

SPACE RESEARCH SATELLITES

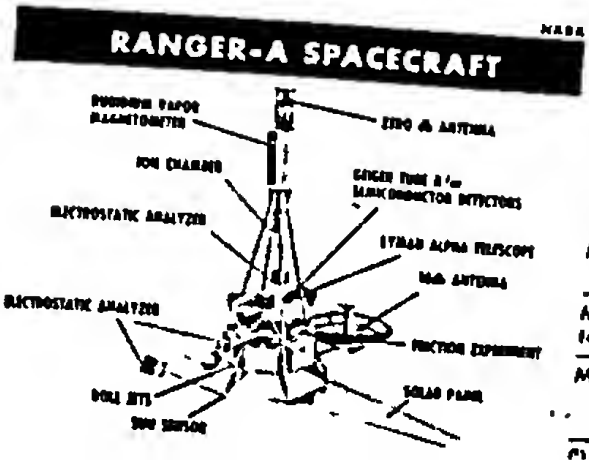
Satellite	Description	Weight (lb)	Operational
Orbiting Solar Observatory (OSO)	Observation of the sun from Space. Satellite is always oriented toward the sun. Transmits observation to the earth.	330	1961/62
Orbiting Astronomical Observatory (OAO)	Star observations from space. Satellite is equipped with telescope and transmits pictures to earth.	about 3,500	1963/64
Orbiting Geophysical Observatory (OGO)	Measurements in terrestrial space and earth observation. Will orbit the earth at various distances and in near-equatorial and polar orbits (POGO)	about 1,000	1963

Various shapes and sizes of space station
be placed in permanent orbits for a varie
duties (left)

NASA

POSSIBLE MANNED SPACE FLIGHT PROGRAM

Project Description	Year of first flight	Vehicle(1)	Time in s
Earth circumnavigation at 120 mi. altitude (Project Mercury)	1961/64	Atlas-Mercury	4 5 hrs.
Extended earth circumnavigation in advanced manned space vehicle (Project Apollo, Phase I)	1965/68	Saturn C-1 Saturn C-2	2 weeks 2 months
Flight around the moon with a crew of three (Project Apollo, Phase II)	1968/69	Saturn C-2 or Saturn C-2 with nuclear stage	Round-trip 1 week
Manned lunar landing	1970/71	Nova	about 2 day one way
Manned reconnaissance flights to Mars and Venus	1973/76	Nuclear space ship	Round-trip ½ to 1½ year
Manned landing on Mars	1976/79	Electrical space ship	Time of absen from earth: 1.5 to 2.5 yea



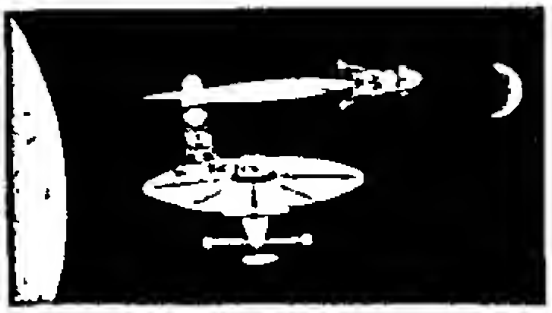
hospitable worlds, such as the moon, offer many advantages over existence in space With the means available to modern man, especially with nuclear power at his disposal and with his technological capability to live independent of his environment, he can exist quite comfortably on the moon, on Mars and possibly also on Venus (although this appears to be more difficult) in an artificial world of his own, much like in the space ships in which he came, but with several important differences.

On Mars or Venus, man has an atmosphere which, although poisonous, nevertheless protects him from the deadly corpuscular space RADIATION. This radiation consists of atomic particles, such as protons, electrons, and neutrons, which cross space at very high velocities, seriously threatening living organisms with the destruction of their tissue. The atmospheres of other planets absorb these as effectively as does Earth's. The space travelers are also protected from METEORITES, pieces of matter (either stone or ice) ranging in size from tiny specks of dust to boulders and larger. They cross space at high speed and might damage or destroy space ships and their crews. Again, any atmosphere protects them more effectively against meteorites than the walls of the space ship possibly could. On the moon where there is no atmosphere, the same protection can be attained by going underground, by drilling tunnels into the side of mountains or by staying at the bottom of some of the deep rills and cracks in the lunar surface.

CREATING ARTIFICIAL CONDITIONS FOR HUMAN LIFE

Another important point to consider is that man's modern chemical and nuclear technology can literally turn stone into food and water by extracting the proper elements, such as nitrogen, oxygen and hydrogen. Thus, while empty space offers him no conceivable means of support, keeping him dependent upon the earth for all new supplies, there is hope that the inhabitants of a base on the moon, Mars or Venus, will, in time, become largely or completely self-sufficient.

Man, with his modern means, can live and work on his neighboring worlds, at least on the moon and on Mars. The most important ultimate purpose of astronautics is to provide him with the means to get to these and to other worlds, eventually to the very limits of the solar system and, perhaps, beyond to the stars.



Courtesy Society For Visual Education, Inc

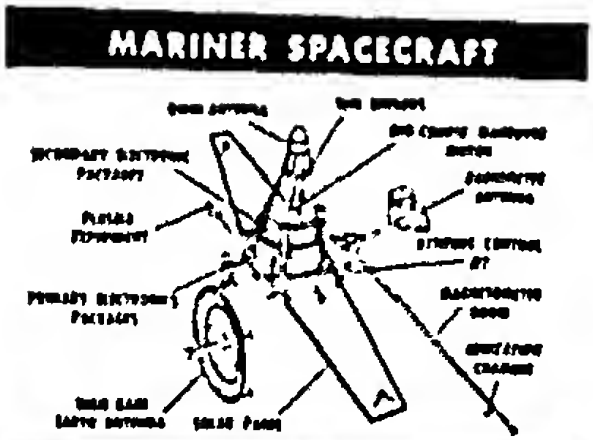
Moon travelers may depart from space depots

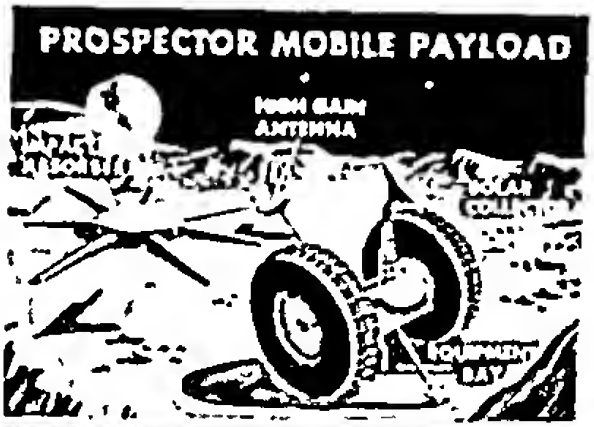
EXPLORING WITH MANNED AND UNMANNED SPACECRAFT

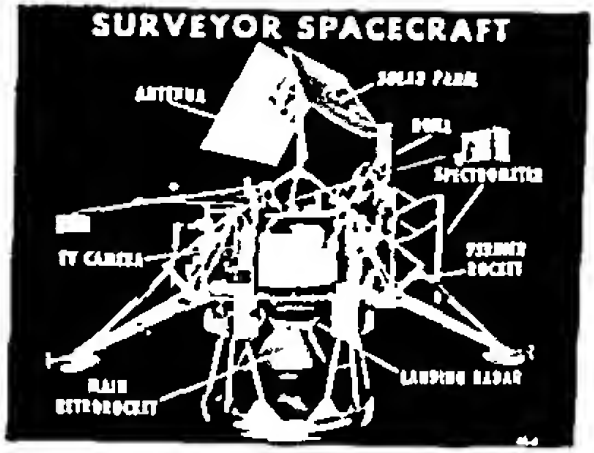
Before he himself can go, however, man must explore space and the conditions on other worlds in more detail than he can from his place on the earth's surface. He does this by sending out small robot space vehicles, often called *spacecraft*. They are, technologically speaking, the forerunners of the large manned space ships of the future. Once he has explored sufficiently the conditions in certain regions of space and on another world, man gets ready to travel himself to this world and explore it in still more detail. Man usually will not stay in space, but rather cross space on his way to other worlds. Because of the many dangers to which he is exposed in space and because of the limited living area which even large space ships offer (after all, flights to the moon take days; to other planets, months or years) he will try always to cross space as rapidly as possible. For this he needs space ships which have engines much more powerful and efficient than those of the little unmanned spacecraft.

PRACTICAL USES OF SPACE

Finally, as man's space capability progresses, he will be able to *utilize* it, in addition to *exploring* it. The small unmanned spacecraft with their intricate automatic equipment and electronic brains can be turned into earth satellites for improved weather prediction and for communication, serving as a global post office or as global television stations. The manned space ships will serve to get man in a routine fashion to his extra







NASA

away from the earth—research grounds, to research monitoring stations on ASTEROIDS in special orbits (for example Icarus, which periodically gets closer to the sun than even Mercury), to his biological testing grounds on Mars or Venus or to his fascinating research bases on Jupiter's large moon Callisto, which is bigger than planet Mercury, or to SATURN'S moon Titan, the only moon in the solar system known to possess an atmosphere. Alternately, man will build large space stations near the earth to implement the activities of his unmanned satellites.

Astronautics, therefore, can be divided into three basic parts: (1) exploration of space and of other worlds by means of unmanned spacecraft; (2) exploration of other worlds by means of manned space ships and (3) practical utilization of space for man by means of unmanned and manned space vehicles.

The utilization of other worlds, by establishing research bases, for example, cannot be considered properly as astronautics (which means navigation to the, or among the, stars), but is part of the surface technology of the respective world.

EXPLORATION PROGRAM

Preparations for the exploration of space and other worlds are under way. First, a number of satellites will be established to explore the earth from space. This would be preparatory to going to the moon. Secondly, a program for the exploration of the moon itself has been worked out. Thirdly, an interplanetary space research program is planned and finally, a program of planetary exploration. The table on the following page lists the periods during which planetary probes can be launched and their progressively more ambitious missions during the sixties and seventies. The launch periods are calculated on the basis of a three to four month travel time to Venus, a six to seven month travel time to Mars and a two year travel time to Jupiter. The missions in at least the first half of the nineteen-sixties will be flown with chemically-propelled spacecraft. Thereafter, electrically-propelled spacecraft will probably be used. These vehicles are propelled not by the discharge of combustion gases, but by the discharge of electrical particles at very high speed.

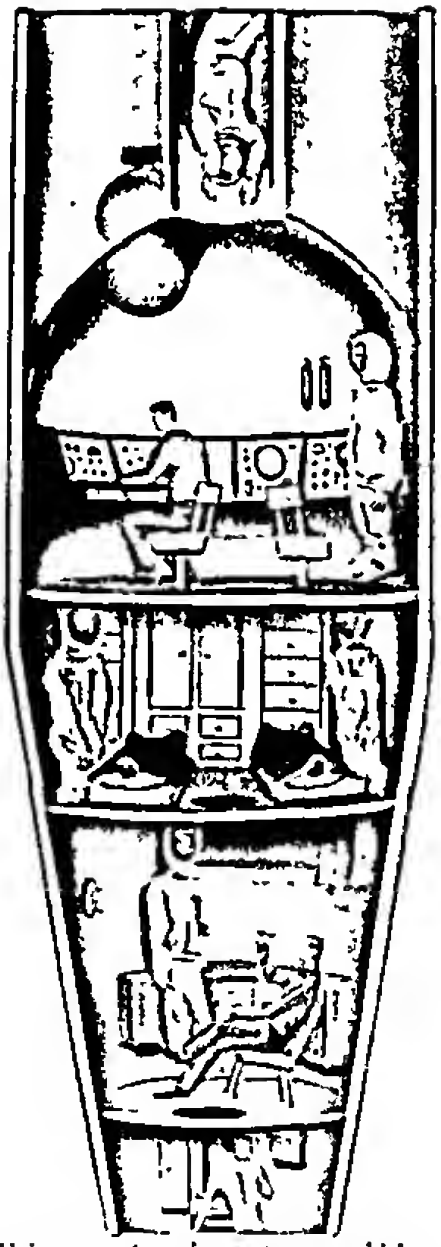
The manned space flight program began in 1961 with the boosting of a Soviet piloted space capsule into an orbit around the Earth. The capsule circled the globe in 108 minutes and was brought safely back to earth. Successful completion of this flight by Major Yuri Gagarin proved that man can live and perform useful work in space.

The American project *Mercury* has sent five astronauts through space in both suborbital and orbital flights. Each of the astronauts had effective control over their own capsules instead of just being passengers. With the information gained from these flights, Americans can expect a manned space flight program of approximately the type summarized on page 160.

PLANETARY AND INTERPLANETARY PROBES[1]

Planet or Space Region	Launch Period of Probe	Vehicle	Weight (lb)	Description of Mission
Venus	July-Sept. 1962	Mariner A	1150	Fly-by Venus measuring magnetic field, radiation belt, atmosphere mass of planet.
Mars	Oct.-Dec. 1962	—	—	No probe planned.
Venus	Feb.-April 1964	Mariner A	1150	Venus fly-by.
Mars	Nov. '64-Jan. '65	Mariner B	1150	Mars satellite and landing capsule.
Venus	Sept.-Nov. 1965	Voyager	about 3000	Venus satellite and landing capsule.
Extra Ecliptic	about 1967/68		about 6000	Flight outside the ecliptic to measure space environment.
Planetoid Icarus	1968 when it approaches the earth to about 4,000 000 miles		about 6000	Landing a scientific monitor station on Icarus whose orbit approaches the sun more closely than Mercury and recedes farther from the sun than Mars.
Mars	Dec. '66-Feb. '67	Electrically propelled spacecraft	about 9000	Mars satellite and landing probe.
Venus	May-July 1967	Electrically propelled spacecraft	about 9000	Venus satellite and landing probe.
Mercury	1967 or 1968	Electrically propelled spacecraft	about 9000	Mercury satellite and landing probe.
Mars	Jan.-March 1969	Electrically propelled spacecraft	about 9000	Mars satellite and landing probe.
Jupiter	Jan. 1972	Electrically propelled spacecraft	about 18,000	Jupiter satellite.
Saturn	May 1974	Electrically propelled spacecraft	about 18,000	Saturn satellite.

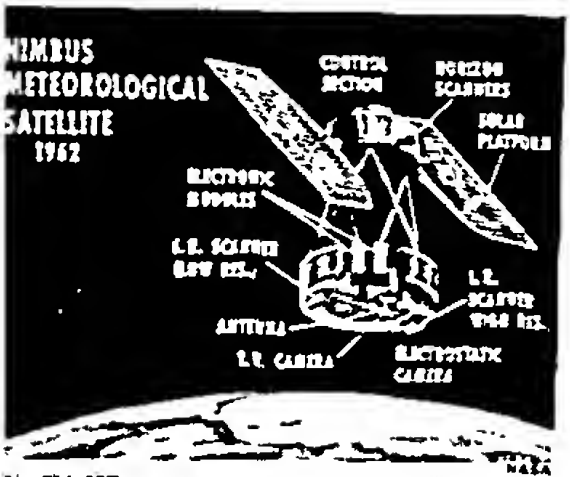
[1]Missions beyond 1965 represent estimates by the author. The launch periods are determined by the motions of earth and target planet.

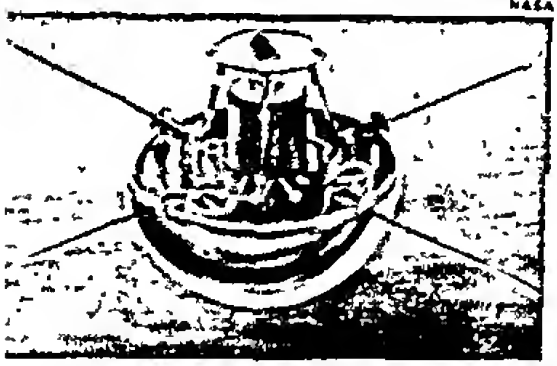


Living quarters in a space vehicle—from the top: air lock, control room and laboratory, sleeping room, galley and recreation room, sanitary room

The next step beyond project *Mercury* is project *Apollo*. Its purpose is to develop a space ship which allows man to stay in space over extended periods of time and to do useful work while in space. Project *Apollo* will raise the flight time in space from hours to days *Apollo* will eventually lead to the establishment of functional space stations in which a crew of many people can live in comparative comfort and carry out space research as well as many important experiments in the vacuum and under weightless conditions

Following project *Apollo*, comes the lunar landing mission. This will be the first step toward a manned moon base. The vehicle which will be used for lunar landings must already be on an energy level which is comparable to that of a manned reconnaissance vehicle to Venus and Mars (which would not yet carry out planetary landings). The reason for this is that breaking the fall toward the moon by means of retro-rockets (since the moon has no atmosphere to slow the oncoming vehicle down) and re-ascending from its surface requires as much energy, above and beyond the energy required for leaving the earth and returning to it, as would be required for a fast round trip to Venus or Mars. For this reason it is necessary that the moon ship as well as the Venus or Mars ship must be powered by atomic rocket engines. Therefore, many components of the moon ship are likely to





n-made satellites are placed in orbit around th where the instruments gather information l relay it back to man

METEOROLOGICAL AND COMMUNICATION SATELLITES

Designation	Description	Weight (lb.)	Month & Year	A
METEOROLOGICAL SATELLITES				
Tiros I	TV pictures of cloud cover	270	April '60	N
Tiros II	TV and infra-red scanner	280	Nov. '60	N
Tiros III	TV and infra-red scanner	280	1961	N
Nimbus I	Advanced meteorological satellite	600-700	1962	N
Nimbus II	Advanced meteorological satellite	600-700	1963	N
Nimbus III	Advanced meteorological satellite	600-700	1963	N
Aeros I, II	24-hr. orbit meteorological satellite	1000-1500	1964	N
Aeros III, IV	24-hr. orbit meteorological satellite	1000-1500	1965	N.
COMMUNICATION SATELLITES				
Echo I	Balloon reflector satellite	132	Dec. '60	NJ
Echo II, III	Advanced balloon reflector satellite	about 150	1961/62	NJ
Relayed	Multiple balloon reflector satellites		1963/65	GC
Courier	Active communication satellite	500	Oct. '60	DO
Advent	Active communication satellite in 24-hr. orbit	1100	1963	DO

be the same as those used for the subsequent reconnaissance flights to Venus and Mars. This method not only speeds the advent of the first manned flight into the depth of interplanetary space, but also increases the reliability of the equipment and reduces the cost of preparing these expeditions.

PRACTICAL USES OF ARTIFICIAL SATELLITES

The practical utilization of space by means of unmanned space vehicles will, in the next ten years, concentrate primarily on two areas: meteorological satellites and communication satellites. A survey of these satellites is presented above

The purpose of meteorological satellites is to provide surveillance of the earth's cloud cover on a global scale, in order to attain a better understanding and improve the prediction of local weather. Already the first meteorological satellite, *Tiros I*, was quite successful. It functioned in orbit for three months and during this period produced almost 23,000 pictures of the earth's cloud cover. Its equipment, however, only allowed the taking of pictures of the earth's sunlit side. Tiros II was equipped with an infra-red "eye," one which "sees" heat waves, hence "sees" objects in the dark, in addition to its regular TV camera and therefore, could observe both the day and night sides. The Tiros satellites are *spin-stabilized*, that is, they rotate about one axis, the one in which their camera is located In this fixed position, the camera looks at the earth only during half of each revolution Its successor, the *Nimbus*, will have a stabilization system to keep the cameras pointed to the earth at all times. Both Tiros and Nimbus circle the earth at a relatively low altitude of 350 to 500 miles Their successor will, therefore, still overlook only a relatively small portion of the globe

The *Aeros* satellite will be established in an orbit which is 23,300 miles high In this orbit the satellite overlooks almost one half of the globe at one glance Moreover, if the satellite is over the equator, it would appear to stand still over one point on the earth because it revolves once in its orbit in the same time the earth rotates once about its axis, namely 24 hours This orbit is called a *24-hour orbit*

Communication satellites can be divided into *active* and *passive* types The passive types merely reflect radio waves, like a mirror reflects light waves They require no electrical power Signals which are sent to the satellite from a point over the United

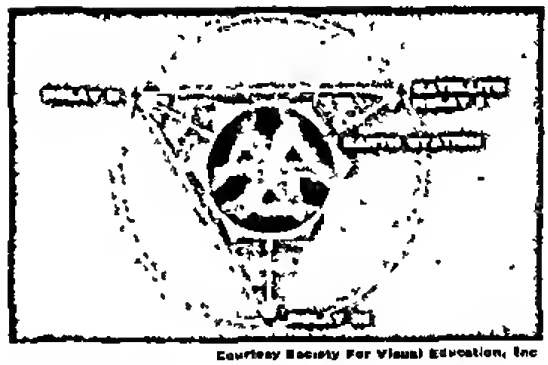
States at 800 to 1200 miles altitude) from a station on the east coast, bounce back on its surface and can be received on the west coast, or vice versa. The satellite can be of spherical shape, but must be rather large (a hundred feet or more in diameter). In order to package such a satellite in the space of a rocket nose cone, it must be collapsible; in other words it must be a balloon which can be inflated once in space.

The first collapsible satellite, *Echo I*, proved to be a great success. A 100 foot diameter balloon in space, it was made of a thin plastic film only 0.0005 inches thick, coated with aluminum to better reflect the signals. Because its skin was so thin, the ten-story high balloon weighed only 136 pounds and, when folded together could be packed into a little sphere slightly over two feet in diameter. After the balloon had reached its orbital altitude of 800 to 1000 miles, inflation was accomplished with the aid of a sublimating (gas-producing) material stored within the balloon. The Echo satellite reflected many messages between stations on the east and west coasts of the United States.

A balloon with such a thin skin is easily punctured by small meteorites. Then the gas, which inflated it, escapes, but the balloon still does not collapse, as it would on Earth, because it is in the vacuum of space. However, even at this altitude there exist remnants of the earth's atmosphere. The ever so tiny forces exerted by these atmospheric gases, resisting the satellite's motion, deform the balloon slightly, distorting its capability to reflect signals. The more advanced Echo satellites will have their hulls stiffened by a chemical which is sprayed automatically on the balloon's inside once it is inflated. This should give Echo satellites in 800 to 1000 miles high orbits a very long useful lifetime.

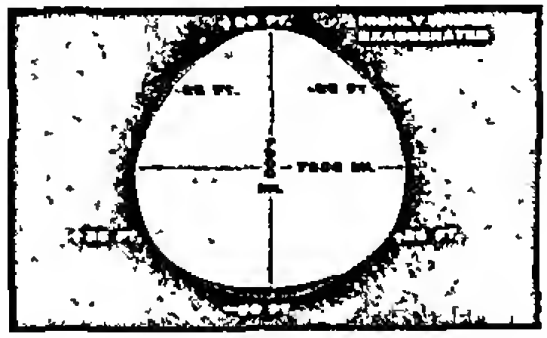
Once this problem is solved, experiments will be conducted by NASA (National Aeronautics and Space Administration) with a large number of such satellites injected into a given orbit. This is project *Rebound*. In order to establish an economic and continuous communication link between America and Europe, for example, 12 to 30 satellite balloons would be required, depending on the orbital altitude (the higher, the fewer satellites are required).

While NASA plans to experiment pri-



Courtesy Society For Visual Education, Inc

Three communications satellites could send radio and TV broadcasts to all parts of Earth



Courtesy Society For Visual Education Inc.

Movements of Vanguard satellites have shown Earth to be slightly pear-shaped

marily with passive communication satellites, the DOD (Department of Defense) develops the active types. These will not simply reflect a signal, but receive it and, either immediately or upon command, retransmit it either at the same frequency or at a different frequency, and either in all directions or in a given preferred direction These active types are, therefore, tiny radio stations in space, requiring electrical power and being in general more complex than the passive types.

The first of these active types was the *Courier* satellite, launched into a 600 to 750 mile high orbit and transmitting well. A more powerful active communication satellite (*Advent*) will be launched into the 24-hour orbit in 1963 as the first step toward a global communication network. Thus, as the dates in the tables show, space utilization will begin to bring interesting and important benefits in less than ten years after the beginning of space flight. As time goes on, astronautics will make the vast space beyond the atmosphere more and more firmly a part of man's world.

K. A. E.

SEE ALSO: ASTRONAUT, COSMONAUT, ROCKETS, SPACE MEDICINE, SPACE TRAVEL, SPACE VEHICLES

Stars never before seen or analyzed are now being "discovered" by radio telescope

Astronomy Astronomy is the study of the heavenly bodies. The sun, moon, planets, stars, meteors, comets, and outer space itself are the objects of study for astronomers. Astronomy is one of the oldest sciences, and it probably has the most interesting and exciting future.

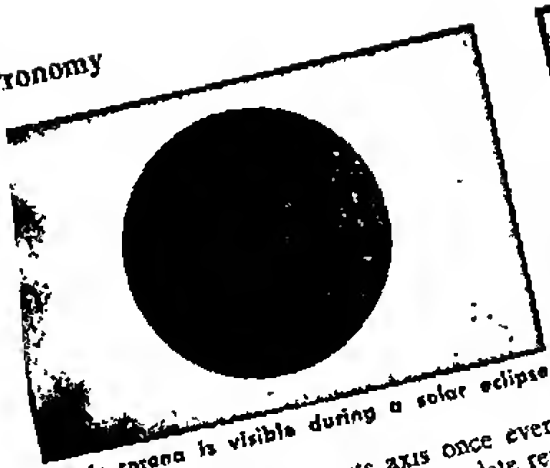
The earliest men on Earth saw the moon and the beautiful patterns of the stars at night. During the day they were aware of the large light in the SKY, the SUN, which is now known to be a necessity to life on Earth. They wondered what caused DAY AND NIGHT and what caused the regular changes of SEASONS. The very earliest practical application of the study of the skies was the making of CLOCKS and CALENDARS to measure time. Early farmers needed a calendar to know when to plant their seeds so that their crops would survive. Because of their ability to predict the seasons, the men who studied the stars were considered very wise. People believed that they could predict and explain all kinds of happenings. The unscientific attempts to interpret man's past and predict his future by the stars is called ASTROLOGY. Some people still believe in it.

The ancient concept of the universe seems very simple and limited today. Many years ago men believed that the earth was flat and that the sky was a large dome, or bowl, that fitted over the earth. The sun, the moon, and the stars were lamps that were hung inside the dome. Later, when it was supposed that Earth was round, men thought Earth was the center of the universe and that the heavenly bodies revolved around it. COPERNICUS, an early astronomer, observed the skies for many years. Near his death he published a theory that the sun, not the earth, was the center around which the heavenly bodies revolved. GALILEO helped to publicize and prove this theory. The idea that Earth was not the center of the universe was a difficult one for men to accept. It contradicted their religious beliefs and their established self-centeredness. Galileo, when he was old and sick, was forced to publicly deny the idea that he had come to believe.

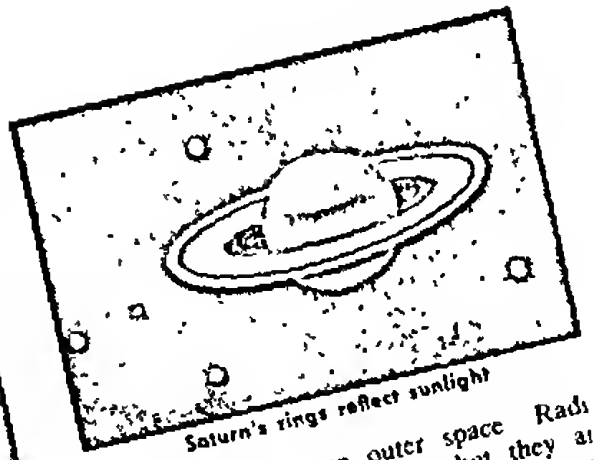
Galileo was one of the first astronomers to have the help of the TELESCOPE to study the skies. With this new invention in the sixteenth century, many discoveries were made. New stars and new planets could be seen The MILKY WAY was seen to be a mass of individual stars.

With a truer understanding of the relationship between the sun and the planets, and with more and more powerful and accurate telescopes, astronomers began to piece together more knowledge about the heavens, to extend the limits of space, and to come nearer the modern view of the universe

Today it is known that the sun is just one of the billions of stars that are in the universe. There are nine known planets revolving around the sun: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. The sun and the planets that revolve around it are called a SOLAR SYSTEM Future astronomers may discover that there are other solar systems, perhaps with life of some kind in them



Sun's corona is visible during a solar eclipse



Saturn's rings reflect sunlight

The earth rotates on its AXIS once every twenty-four hours. It makes a complete revolution around the sun in about 365¼ days. A body that revolves around another is called a SATELLITE. Earth and the other planets are satellites of the sun. The moon is a satellite of the earth. Jupiter has 12 moons. Modern men are sending man-made satellites into orbit.

The invention of the telescope led to the discovery of the true nature of the movements of the planets around the sun. It was learned that the paths of the planets are not exactly circular. They are elliptical (oval). Astronomers could watch and chart the movements of heavenly bodies. They could measure the speed of and distances between the objects in space. When SIR ISAAC NEWTON proposed the theory about the law of gravity, astronomers began to understand why the heavenly bodies move as they do. The interaction of gravitational forces accounts for the relative positions of the planets and keeps them in their orbits. EINSTEIN's theory of RELATIVITY led to further refinements of the science of celestial (star) mechanics.

The development of new techniques and new instruments is leading to a rapid accumulation of astronomical knowledge. Modern astronomers are aided in their research by the 200-inch Hale reflector, the largest optical telescope in the world, located in California on Palomar Mountain. With the use of SPECTROSCOPES they study the light of stars. The spectrum of the light of a star can tell the astronomer what chemicals are in the star. Spectroscopy can also reveal information about temperature, pressure, [illegible] field of [illegible] of stars.

arrive at earth from outer space. Radi waves are like light waves, but they ar longer than light waves. Radio waves c be studied with a RADIO TELESCOPE. Hea enly bodies that are always behind clou or dust can now be studied.

Rockets, satellites, and SPACE probes a are leading to advances in astrono Spectrographs, cameras, telescopes, recorders that are sent into space can information that men could never get earth. Telescopes in balloons revealed the atmosphere of Venus contains vapor. Cameras have photographed other side of the moon, which always away from Earth. Astronomers can i information from lunar probes to stu moon's magnetic field. This is an e era of space research.

Astronomy is practical. It kee clocks and calendars accurate, it h produce NAVIGATION charts and t sea and air, and it provides inform WEATHER FORECASTING. Astronom portant in releasing the energ hydrogen atom. But astronomy the key to imagination and wo did the universe begin? What to it? Where does it end? Are beings like man on some o Could men travel far into spa

The knowledge of astrono important in the developm TRAVEL. Once men do get will still need the astronome is the moon or another plan to know whether the surfa landing and what kind o supplies to take. They w which way and how fast being smashed by a plan with a white-hot star

Astrophysics Astrophysics is a science which deals with the constitution, physical characteristics, and motions of STARS and other celestial bodies. In *astrophysics, the theories of PHYSICS* are applied to ASTRONOMY.

Asymmetry see Animals, classification of; Protozoa

Atavism Atavism is the reappearance in a living being of characteristics which have not been in its ancestors for several generations.

SEE: HEREDITY

Atlantic Ocean see Oceanography

Atlas see Rocket

Atmosphere *(AT-muss-fere)* All around the earth, like a protecting blanket, lies the earth's atmosphere. Men have been at work since the beginning of time trying to find out more about it. Now, in the age of air travel and atomic explosions, men must know what air is made of, how it moves, and the forces at work in it.

COMPOSITION

The atmosphere is often described as an ocean of air. Of course, it is much more vast than any ocean of water men know about. Because it is so large, knowledge of it is important. What has been discovered about the atmosphere, however, has increased the scope of air travel and made radio and television possible. Some meteorologists who study weather think the atmosphere is about 600 miles thick. They know it has four properties that keep people alive: (1) the power to protect the earth from dangerous extremes of heat and cold; (2) the necessary gas for life—OXYGEN; (3) the ability to screen out the deadly portions of the sun's rays; and (4) the ability to store and carry moisture.

The atmosphere, or band of air around the earth, is very small compared to Earth's size

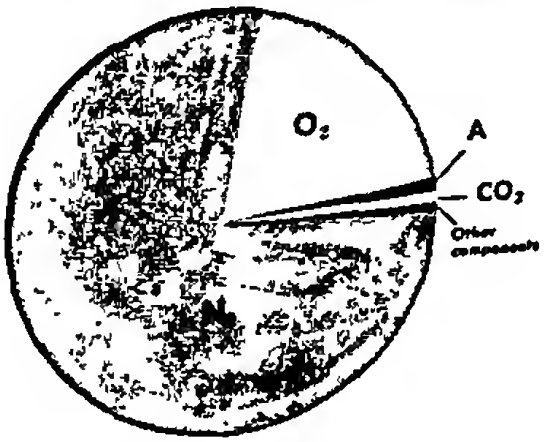
CONSTANT COMPONENTS OF THE ATMOSPHERE

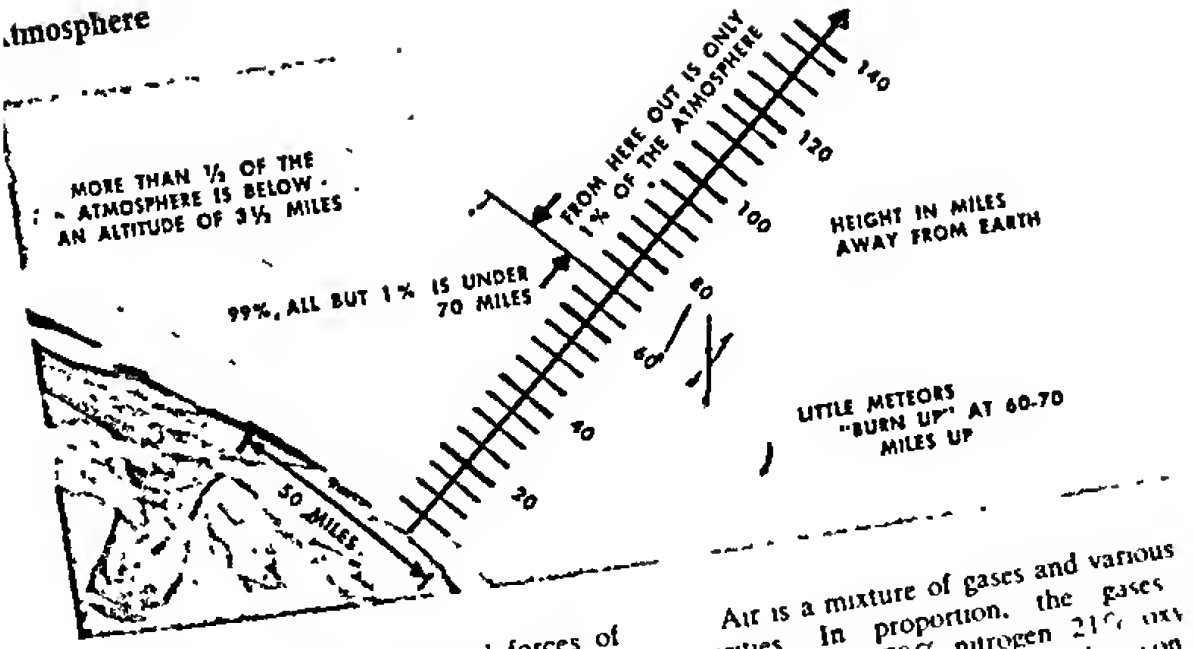
Nitrogen	N_2	78.084%
Oxygen	O_2	20.946%
Argon	A	0.934%
Carbon Dioxide	CO_2	0.033%
Neon	Ne	0.00001818%
Helium	He	0.00000524%
Methane	CH_4	0.000002%
Krypton	Kr	0.00000114%
Hydrogen	H_2	0.0000005%
Nitrous Oxide	N_2O	0.0000005%
Xenon	Xe	0.000000087%

VARIABLE COMPONENTS OF THE ATMOSPHERE

Water vapor	H_2O
Ozone	O_3
Hydrogen peroxide	H_2O_2
Ammonia	NH_3
Sulfureted hydrogen	H_2S
Sulfur dioxide	SO_2
Sulfur trioxide	SO_3
Carbon monoxide	CO
Radon	Rn
Dust, soot, salt particles	

Composition of the atmosphere on a circle graph





The balance among gases and forces of the earth's atmosphere is a part of the miraculous pattern of the universe. Because the balance of gases in the atmosphere differs from that in areas surrounding other planets, one wonders whether life on other planets is possible. This balance seems to maintain itself through the proper number of plants and animals on Earth.

If the air stopped moving, no wind would blow life-giving warm air into the frigid regions, or bring life-saving cool air to the unbearably hot tropical regions. There would be no medium to carry moisture from the sea to the thirsty land.

The sun is the source of ENERGY that causes winds. Radiant energy from the sun falls upon the earth. Some of the energy, while passing through the air, is turned into heat energy, but most of it passes through the air to the earth. A small amount of radiant energy is reflected by the clouds and the earth and is lost in space. Unequal heating of the earth and water causes the air to move in the form of wind from place to place. The rotation of the earth influences the wind's direction. Land heats more rapidly than water, and the air over land becomes warmer than the air over water [illegible] air is more dense and exerts [illegible] expanded

Air is a mixture of gases and various impurities. In proportion, the gases are approximately 78% nitrogen, 21% oxy[illegible] and 1% other gases. Air also contains variable amounts of water vapor. The table on the preceding page is a more p[illegible] analysis of the gases in air.

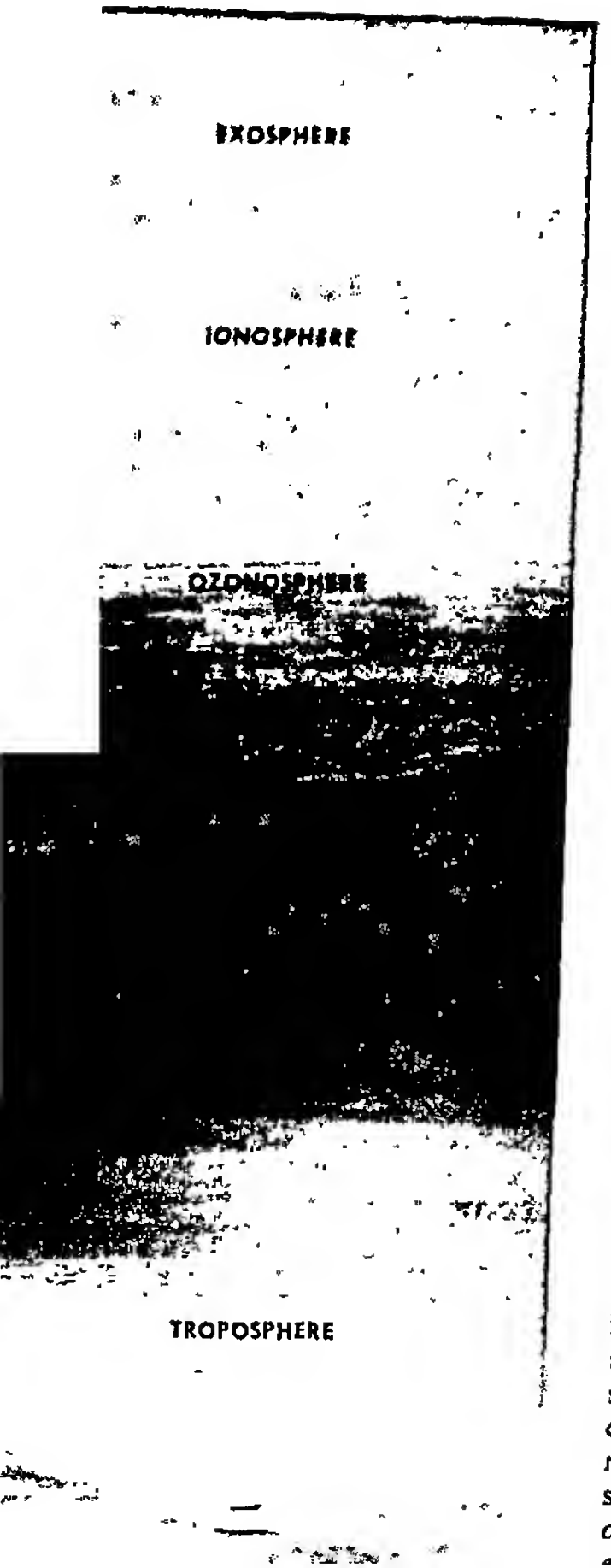
Much knowledge about the natu[illegible] gases was revealed through the studies of ROBERT BOYLE, around the middle of the 17th century, and by JACQUES C[illegible] about one hundred years later. Th[illegible] plored the relationships of volume p[illegible] and temperature, and laid the fou[illegible] for present day analysis of air mo[illegible]

The phenomenon of AIR PRESS[illegible] density was explained as early as the Italian Torricelli, whose famou[illegible] ments with a glass tube filled with made possible the measuring of in air pressure.

The history of oxygen is one o[illegible] interesting stories written by men. Oxygen was not always a part of atmosphere, but appeared long gases as nitrogen, carbon dioxid[illegible] vapor.

ORIGIN

The origin of the atmosphere a part of the origin of the earth is estimated to have taken pla[illegible] years ago, and [illegible]



velocity of the gas molecules, because of high temperature, allowed most of them to escape the gravitational field into outer space.

As the earth grew colder, changes took place on its crust and in its atmosphere. Water vapor, nitrogen and carbon dioxide which had been dissolved in the liquid rock began to fill the air. In modern times, volcanic eruptions give some idea of the composition of the atmosphere at this stage of its development. It was still highly poisonous.

Eventually rain reached the earth, forming rivers, lakes and oceans. Large amounts of carbon dioxide in the atmosphere became part of the earth's crust or dissolved in the oceans. The components which were to make the development of life possible in later ages were already evident in the atmosphere, according to such scientists as Oparin and Urey. Then the thick dark clouds surrounding the earth parted and allowed sunlight to penetrate for the first time. There followed a period of gigantic storms and great upheaval. During this time, organic substances entered their first phase. Then oxygen made its appearance. How it arrived upon the scene at the right time is the subject of a number of theories, but it is certain that once oxygen was present in the atmosphere, the evolution of higher life and man from primitive cells was possible.

LAYERS

The atmosphere may be divided into layers, or zones, each with its own characteristics. The layer which people move about in every day, and which is said to extend to an elevation of about 35,000 feet is called the *troposphere*. This is a suitable name because troposphere means "region of turning, or change," and in this layer weather changes take place. Above it is a thin layer, the *tropopause*, that separates the troposphere from the stratosphere. The name *stratosphere* comes from the Latin word *stratum*, meaning "layer." Above the stratosphere are three more layers—the *ozonosphere*, the *ionosphere*, and the *exosphere*.

The outer edge of any given part of the troposphere varies according to its position in relation to the earth. Where it measures about five miles at the poles, it increases to eleven miles in depth at the equator. This variation is due to the greater density of the air over the cold polar region. The CENTRIFUGAL force at the equator causes the air to bulge out from the earth. The warm air over the equatorial region is less dense than that over the polar region.

In the troposphere meteorological changes take place as cold, dry air masses meet warmer, damper ones. Generally speaking, as one ascends into the atmosphere both air pressure and temperature decrease. The weight of the air causes a dense gathering of molecules at sea level to which man's body is adjusted. Six miles above the earth, however, the air is already so thin—the molecules so far apart—that a man would soon suffocate. Pressurized cabins on airplanes have been designed for survival of people. Man has similarly adjusted to sea level temperatures and would find it impossible to live through the temperature change in an unprotected ascent into the troposphere. From 20°C at sea level, the thermometer falls to minus 50° to minus 80°, depending upon the starting point.

Up that far, the sky appears deep blue and cloudless, more blue than when viewed from earth. At high altitudes, there are few particles of dust or clouds to scatter the light, as they do close to the surface. Clouds also help to absorb or screen out the wave lengths of the sun which are harmful to man. Farther out in the atmosphere, the sun's rays meet far fewer air particles to break them up and disperse them. The sky then looks black and the sun stands forth in glaring white intensity.

Unlike the troposphere, the *stratosphere* is characterized by clear, dry air which is extremely thin. No rain or snow exists here, not even clouds. There is so little air pressure at this height of about fourteen miles that a man's blood would literally boil if he left the protection of his cabin where near normal pressures are maintained for him. The temperature, too, has constantly dropped, and continues to do this until the ozonosphere is reached.

In the *ozonosphere* the thermometer shows an increase in temperature, long a puzzle to investigators. All the physico-

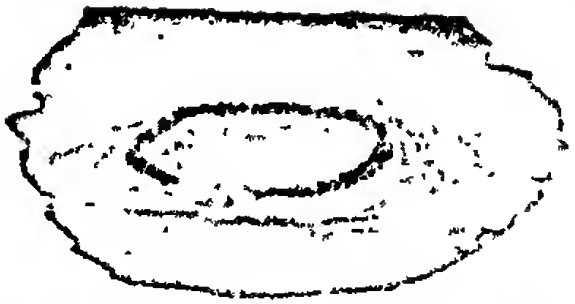
If a satellite comes back into the lower parts of the atmosphere, it may burn up

chemical reactions which take place in this area are far from being understood, but it is known that the action of short RADIATION on the oxygen molecules causes them to split and somehow form a new substance, OZONE. During the process, heat is liberated to the extent the thermometer rises to more than 30° C at 32 miles up. Although the ozone formed is itself poisonous, this layer is called a life-saving one, because the damaging ultra-violet rays from the sun lose much of their power here when they become involved in converting oxygen into ozone. Animal and plant life is again protected and preserved.

Above the ozone layer, the temperature again falls to minus 70° C. Going into the *ionosphere*, the air molecules are so far apart they no longer transmit sound of any kind. All is silence. From this height, the curvature of the earth can be clearly seen against the black sky. The surface of the earth appears as an indistinct design. The identifying characteristic of this layer is the change in electrical action. The air is now electrically charged, and most scientists describe the ionosphere in terms of electrical layers. This part of the atmosphere accounts for the ghostly polar lights, AURORA BOREALIS and aurora australis, and the reflection and transmission of radio waves.

On the outer edge of the atmosphere, the air trails thinly into space, much as the smoke of a campfire seems to float outward and disappear into the air. The gravitational pull at this point acts very weakly on the air particles, some of them escaping into outer space, others bouncing back into lower layers. This last layer is called *exosphere*, from the Greek word, *exo*, meaning "outside." This is the uppermost portion of the atmosphere surrounding earth. Beyond this, SPACE begins. E. M. N.

SEE ALSO: EARTH, SPACE MEDICINE



Atolls are built up bit by bit as coral skeletons are deposited

Atoll (AT-ol) An atoll is an ISLAND built by tiny animals that live in warm ocean waters. These are called coral animals and their skeletons form coral rock. CORAL is formed where water is not deep. Coral islands or atolls may be formed on tops of underwater mountains or old volcanoes that are just below the surface. Coral is built up on these mountain tops for many years until it comes to the surface.

An atoll is either circular or horseshoe in shape and surrounds a calm lagoon. The islands range from one to one hundred miles around. The depth of the lagoons are from about one hundred to three hundred fifty feet. Atolls are found by the thousands in the tropical areas of the Indian and Pacific oceans.

CHARLES DARWIN'S explanation of their formation is the most believable. First of all, coral animals build a reef along the shore line of a volcanic peak. Then wind and rain gradually wear down and eventually destroy this peak. The reef continues to grow upward, however, only a few feet above the surrounding water. At last only the coral reef remains surrounding the sunken island.

Only a few things live on an atoll. COCONUT palms, breadfruit trees, and PANDANUS trees comprise the plant life. Rats and land crabs are the only animals. Fish can be found in great quantity in the lagoon and the surrounding waters of the reef.

Since the 1940's atolls have achieved some prominence, for it was on Eniwetok and Bikini atolls, for instance, that the atomic and hydrogen bomb experiments took

Atom Suppose that a person could take a piece of gold and divide it into two pieces, take one of these pieces and divide it again, and continue until the tiniest piece of gold could be obtained. That piece or particle would be an atom of gold.

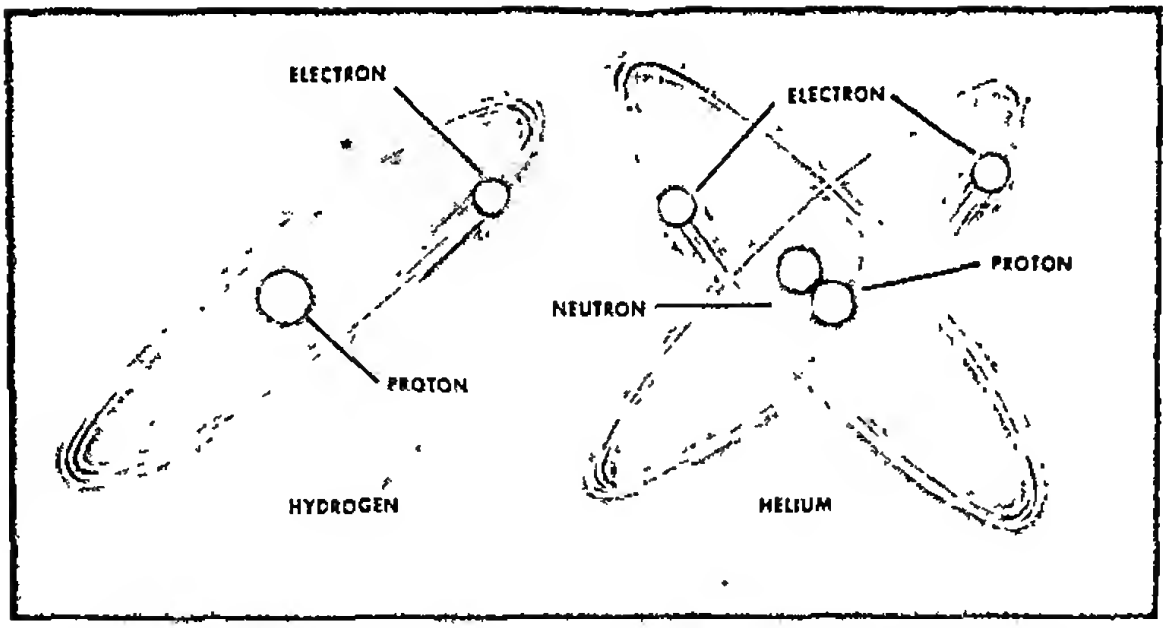
An atom cannot be seen by the naked eye nor by the use of the most powerful microscopes scientists have developed. An atom is so small that it would take 250,000,000 of them placed side by side to measure a space an inch long.

The atom can be considered a miniature solar system with a *nucleus* composed of *neutrons* and *protons* in the center and *electrons* whirling around it much as the planets revolve around the sun.

These subatomic (smaller than an atom) particles are bundles of electrical energy. The electrons carry a *negative* charge and the protons carry a *positive* charge. The neutrons carry *no* charge. Since the number of electrons equals the number of protons, *the atom is electrically neutral.* The number of protons present determines the *atomic number* of an element. For example, the hydrogen atom has one proton and one electron. Its atomic number is one. The helium atom has two protons, two neutrons, and two electrons. Its atomic number is two. All the elements except hydrogen contain electrons, protons and neutrons. Hydrogen has no neutrons. Moreover, all the atoms of one element resemble one another in physical and chemical properties but are *different* from atoms of other elements. All atoms with two electrons would be helium atoms and they would exhibit similar properties. Therefore, the number of protons and the *number of electrons* present determine the particular element.

ATOMIC WEIGHT

The nucleus has most of the weight of the atom although it is 10,000 times smaller than the atom. The proton and the neutron both weigh nearly 2,000 times as much as the electron does. Therefore the weight of the electron is almost negligible in determining the *atomic weight* of an atom.



While the number of electrons and protons in an atom does not change, the number of neutrons can vary. The various forms are called ISOTOPES of an element. For example, uranium can have an atomic weight of 234, 235, or 238.

Since there is no direct method of measuring the weight of atoms, all weight numbers must be relative. Until 1960, the mixture of three natural isotopes of oxygen was the international chemists' standard. Because oxygen atoms were known to contain eight neutrons and eight protons, the standard value of 16.0000 was assigned. Then the atomic weights of all other elements were figured as smaller or larger multiples of the oxygen weight. But in 1960, scientists all agreed to make non-radioactive carbon-12 the standard. As a result, the tables of atomic weights will be reduced by only .000037; and carbon becomes 12.0000, while the natural 3-isotopes oxygen becomes 15.9994. For rough calculations, oxygen may still be taken as 16.

If an atom were made the size of a football stadium, the nucleus would be the size of a B-B shot. Therefore, it would seem that most of the atom is empty space. If this is true, why is it impossible to walk through a door or any other solid object? This phenomenon may be explained by a simple illustration. A propeller of an airplane has three blades which can be seen plainly when the propeller is idle or when the propeller begins to spin. As soon as the airplane is aloft and the blades are spinning at a high rate of speed, they appear to be a solid mass Because electrons move around the nucleus at tremendously high speeds, the same thing happens to an atom.

ATOMIC ACTIVITY

The atoms of one element can combine with the atoms of another element to form compounds. The electrons determine whether or not one element will combine with another element. The electrons also determine how the elements will combine, i.e., by sharing, borrowing, or lending electrons.

The atoms of some elements, particularly METALS, tend to lose electrons and to become positively charged. Other atoms, like those of non-metals, tend to gain electrons and to become negatively charged. The atoms of a few elements do not combine with the atoms of any other elements. All these are gases and include helium, neon, and argon

The atoms of uranium, radium and other heavy elements contain more neutrons than protons. Usually these atoms are not stable and are continually splitting and shooting out particles.

The phenomenon of atoms splitting can be observed by looking at the luminous numbers on a clock or a watch in a darkened room with a magnifying glass. The flickers of light which appear are atoms of radium splitting.

Elements whose atoms split by themselves are called RADIOACTIVE ELEMENTS. Ernest Rutherford, an Australian physicist, discovered that radioactive elements gave off three different kinds of rays. He named these rays after the first three letters of the Greek alphabet. The *alpha rays* were strong but could travel only a short distance. The *beta rays* were weaker but traveled one hundred times as far as the alpha rays. The third rays were more penetrating than the first two and resembled X-RAYS.

Further experimentation revealed that alpha particles (rays) carried a positive charge and that they were actually helium atoms from which two electrons had been removed. Beta particles were electrons shot out of the nucleus of an atom.

In order to understand what happens when atoms split and break down, suppose one started with an ounce of some radioactive element. Imagine that in one hour, half of the material has been used by radioactivity. In another hour, ¼ of the material is left and in still another hour ⅛ of the material is left. The rate slows down as the amount of material diminishes. The time needed for ½ of the radioactive element to disappear is known as the HALF-LIFE of the element.

Radium has a half-life of 1560 years. That means that if one began with one ounce of radium it would take 1560 years for ½ ounce to be used. It would take another 1560 years for ½ of what was left to be used, etc. While radium is breaking down, energy is being given off. There is as much energy given off from one ounce as in the burning of ten tons of coal. It is this energy which scientists are harnessing. V. B. I.

SEE ALSO: CHEMISTRY, NUCLEAR SCIENCE

Atom smasher see Accelerators

Atomic bomb see Bomb

Atomic energy see Nuclear energy

Atomic number see Atom, Elements

Atrophy (AT-truh-fee) Atrophy is the wasting away or decrease in size of a cell, tissue, or organ. It sometimes makes a person unable to move about or to use a part of his body.

Atrophy may be temporary, occurring after a part of the body has been disabled for some time. For example, after a leg has been broken and left in a cast for several weeks, the muscles of the leg become smaller. The leg has to be exercised and the muscles rebuilt through use.

Atrophy of tissues also occurs when nerves supplying them are injured, severed, or affected by disease. If nerve damage is permanent, as in some cases of POLIOMYELITIS, the atrophy is progressive and cannot be stopped. When HORMONES are not circulated in large enough amounts, glands and other tissues which they govern undergo atrophy.

Also, in old age tissues tend to atrophy. The parts most affected by the atrophy of old age are the skin, reproductive organs, muscle and cartilage tissue, and occasionally the brain. V. V. N.

SEE ALSO: ENDOCRINE SYSTEM, MUSCLE SYSTEM

Atropine (AT-truh-pin) Atropine is a drug used in medicine. It is obtained from the leaves and roots of the *belladonna* plant, also known as deadly NIGHTSHADE. It has been used by physicians for many centuries.

Atropine is used to dilate the pupils of the eyes when people are examined for eyeglasses. It reduces the secretions of the glands of the body that are under the control of the AUTONOMIC NERVOUS SYSTEM. It also constricts the blood vessels, relaxes the bronchioles of the lungs, and quickens the heart beat. It is helpful in treating heart failure, asthma, mumps, and in preparing patients for SURGERY.

Atropine has the chemical structure of an *alkaloid*, and is related to caffeine and cocaine. It is antagonistic to the effects of the parasympathetic nervous system. It blocks the action of *acetylcholine*, a *neuro-hormone*, which is released at the nerve ending of parasympathetic fibers in the organ cells in which the action takes place.

The pupils of the eyes become dilated because the muscles that contract the pupil are paralyzed by the atropine. The constrictor muscles of the bronchial tubes and the intestine are inhibited in the same way, so that the bronchioles and intestine are relaxed. The secretions of the salivary and other glands are also suppressed when these tissues no longer receive stimulation from the parasympathetic neurohormone. J. B. O

Attar see Perfume

Audubon, John James (1785-1851)

John Audubon was an American artist who studied birds and painted them in their natural surroundings. He explored the countryside looking for new birds to paint. Audubon also was the first American to put bands on the legs of birds to find out where they flew and how long they lived.

Audubon thought he was born in New Orleans, Louisiana, when Louisiana was still French territory. However, Dr. Francis H. Herrick proved with documentary evidence that he was born in Haiti, the son of a Creole mother and a French father who was a mercantile agent. She seems to have been killed in an uprising in Santa Domingo, but the father and son escaped to France.

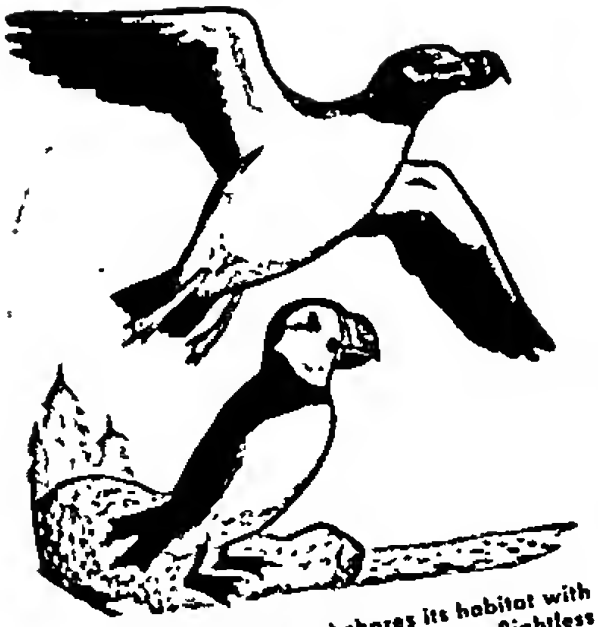
When he was eighteen years old, Audubon came to America to live on his father's estate near Philadelphia. There he began to paint birds from life. That same year he carried on the first bird-banding experiment in the United States.

In 1808 Audubon married and ten years later moved to Kentucky. This move proved important in his life because in Louisville, Kentucky, he met Alexander Wilson, the first American *ornithologist*, or student of birds. He showed Audubon the first two volumes of his study of birds entitled *American Ornithology*.

Audubon's primary interest in life was painting birds in their natural surroundings. He rebelled against painting stuffed birds mounted for museum use, as was the custom of his day. He loved to explore the fields, the hills and the woodlands, looking for new birds to observe and to paint.

In 1826 Audubon went to England to exhibit his drawings of birds and to find a publisher. He later published the drawings in a huge volume entitled *The Birds of America*. This work contained 435 life-sized colored pictures of birds. In 1839, with the help of William MacGillivray, Audubon published *Ornithological Biography*, a descriptive explanation of American birds. His reputation was later established when he published *Synopsis of the Birds of North America*. Audubon then settled on his estate, now Aubudon Park, New York, to enjoy his last years observing and drawing birds.

D. H. J.



The razor-billed auk (top) shares its habitat with its relative the puffin (bottom). The flightless great auk is now extinct

Auk (AWK) Auks are duck-like birds native to the Arctic and northern Atlantic and Pacific oceans. They are awkward on land and in the air but swim well, using their wings for power when they dive for food. Most auks are dark above with white underparts, have curved heavy beaks and three webbed toes. They breed in colonies on the rocky coasts and winter on the open seas. Auks eat mostly plankton and crustaceans.

The *razor-billed auk* breeds on Arctic islands. It is about 16 inches long and is marked by a white line from eye to bill and around the bill

The *dovekie*, a robin-sized small auk, is abundant in the Arctic. Bird and eggs are important sources of food for the Eskimos

There are five species of small auks called *auklets* native to the Pacific. Some have fancy crests or plumes.

The *great auk*, extinct since 1844, was once common in the North Atlantic. It was slaughtered by hunters for its feathers and meat.

E.

Aureomycin see Antibiotics

Auricle see Heart

The Charioteer

Auriga (aw-RY-gah) Auriga is a group of stars that is thought to resemble the driver of a chariot. The main stars of this CONSTELLATION form a five-sided figure in the sky. There is one very bright star in this group. Its name is *Capella*. Near Capella are three fainter stars that form a small triangle. These are called *The Kids*. The best time to look for Auriga is in winter.

Traditionally, the Charioteer is supposed to represent the first chariot-driver, Erichthonius. Erichthonius was the son of Vulcan and Minerva. Because he was crippled and could not get around very well, he invented the horse-drawn chariot. In recognition of this invention, a memorial to him was made in the heavens. Some legends say that the charioteer is Phaeton, the son of Apollo. One day Phaeton borrowed Apollo's chariot, and when he tried to drive it, he was overturned. Capella, the bright, beautiful yellow star, is sometimes called The Goat. The goat and her kids were given a place in the stars because the king of the gods, Jupiter, was supposed to have drunk goat's milk as a baby. Ancient Hebrews called this constellation The Good Shepherd. C. L. K.

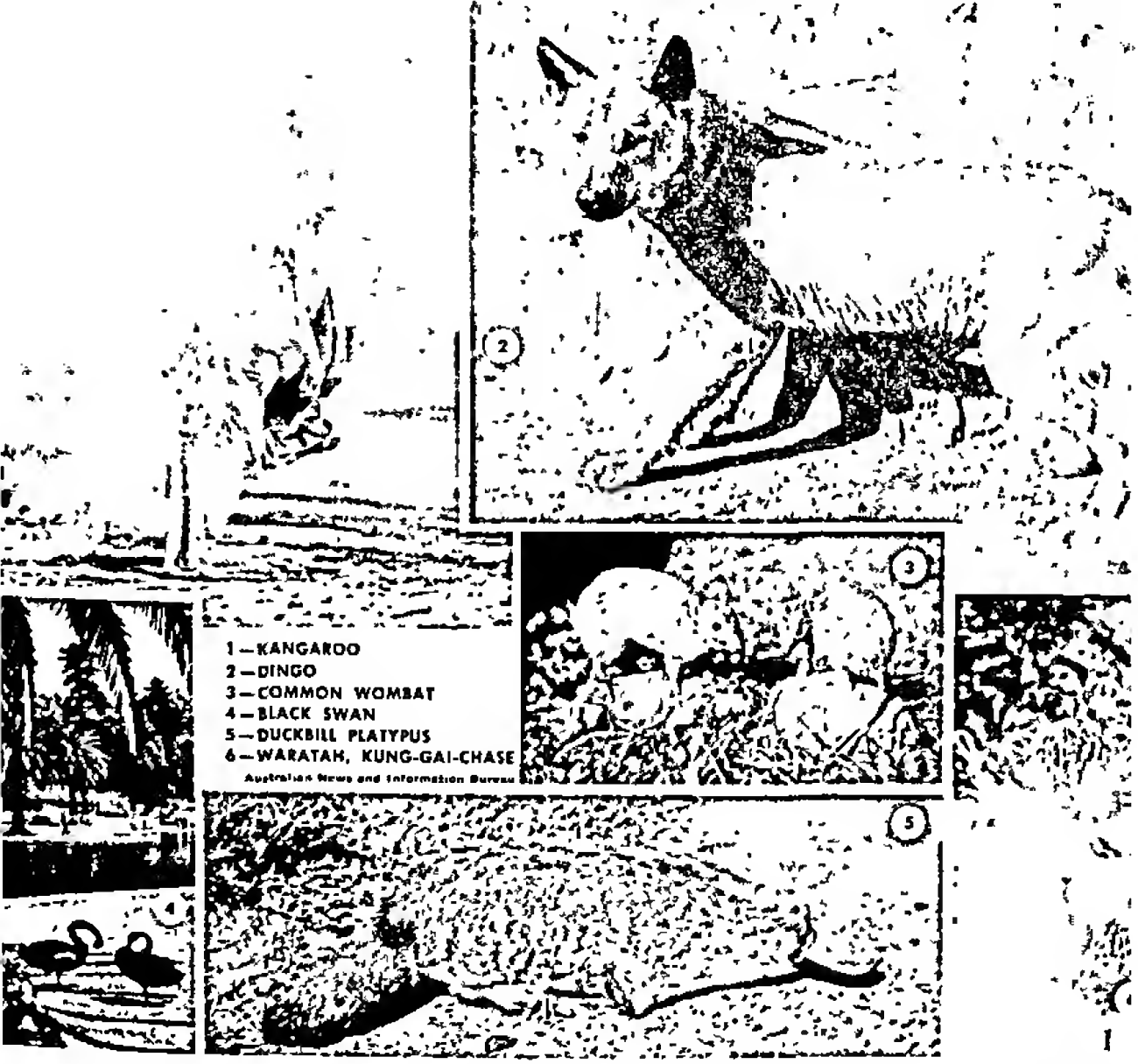
Aurora borealis (uh-RORE-ruh bohr-ree-AL-iss) An aurora borealis is a beautiful display of moving colored lights in the northern night sky. It is sometimes called the Northern Lights. Auroras in the southern part of the world are called the Southern Lights or *aurora australis*. The two are both called *aurora polaris*.

Auroras occur about 60 miles above the earth and may extend for hundreds of miles upward. They are most often green or yellow-green, yellow, and red. Sometimes shades of blue, gray and violet also are seen. The shapes and movements vary widely.

Auroras are believed to be related to *sunspots*, storms on the sun that send off electrical particles. About 60 miles above the earth the atmosphere becomes very thin. There is almost a VACUUM there. When these particles reach the thin atmosphere, they cause the rarefied gases to glow. The varied colors are probably created by the interaction of the electrified particles from the sun with different kinds of gases.

The theory that auroras are electric displays is supported by the fact that they bear a consistent relationship to the magnetic poles. There are definite areas near the north and south poles where auroras occur most frequently. The best area to observe auroras in the northern hemisphere is around the Hudson Bay, where auroras occur about two out of every three nights. Auroras can be seen fairly often in the northern United States. On rare occasions they have been seen even as far south as Florida or Louisiana. C. L. K.

Aurora borealis, or Northern Lights, is a display of color seen in the sky

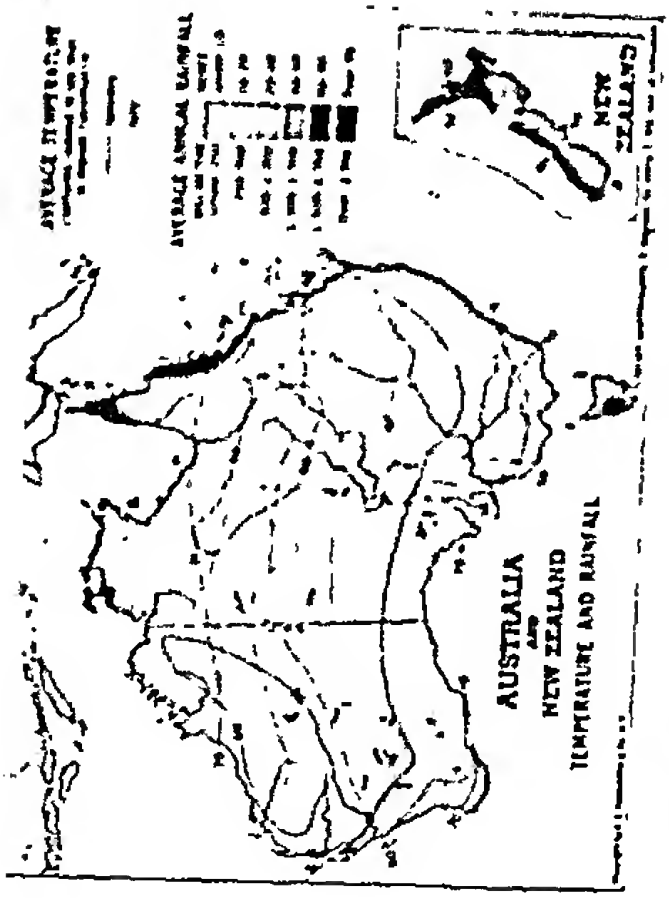


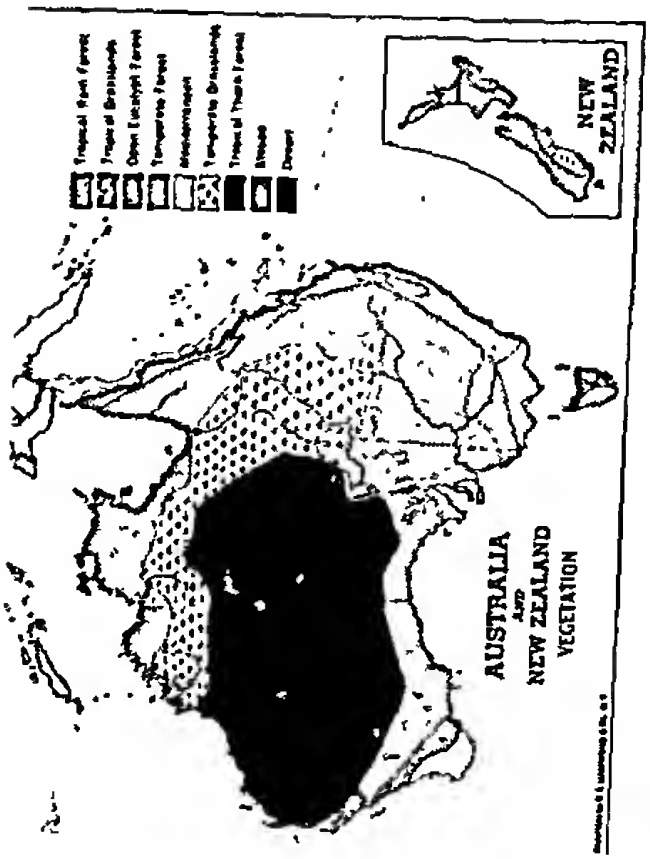
Australia Australia is the smallest CONTINENT, but it is the largest island in the world. Its area is about 3,000,000 square miles, or $\frac{1}{6}$ less than the United States. It lies south of the equator and south of ASIA. It is completely surrounded by waters of the southwest Pacific Ocean and the southeast Indian Ocean. Australia is very far from other lands except southeast Asia and the south Pacific islands. By air, Melbourne is almost 8,000 miles from California, over 7,000 miles from Brazil, 6,000 from Bombay, India, and 5,000 miles from Tokyo, Japan.

Australia is a land of strange animals and plants like the KANGAROO and the bottle tree. They are found nowhere else. Its native people, or *aborigines*, had a very primitive culture before the coming of the white man. This was because of the great distance between them and other peoples from whom they might have learned new ideas. The aborigines live on reservations in the northern tropical region.

LAND FORMS

The central and western parts of Australia are a great PLATEAU with an average elevation of 1,000 feet. Toward the west and northwest, upland ranges may reach 4,000 feet. Eastward from the plateau is a great basin. This plains region is far from being entirely flat. Toward the eastern coast, a





great dividing range of mountains runs north and south. The highest peak in this range is Mt. Kosciusko, over 7,300 feet. The Great Dividing Range has various local names such as the Australian Alps and the Liverpool Range. The width of the mountains is about 150 miles.

A coastal plain lies adjacent to the Pacific Ocean. Its width varies from 50 to 300 miles. Along the coast is the Great Barrier Reef, the longest reef in the world—more than 1250 miles long. The outer face just below the surface is composed of actively growing CORAL. A protected channel for ships lies between this and the shore. At times, tides and hidden rocks make the channel rather dangerous.

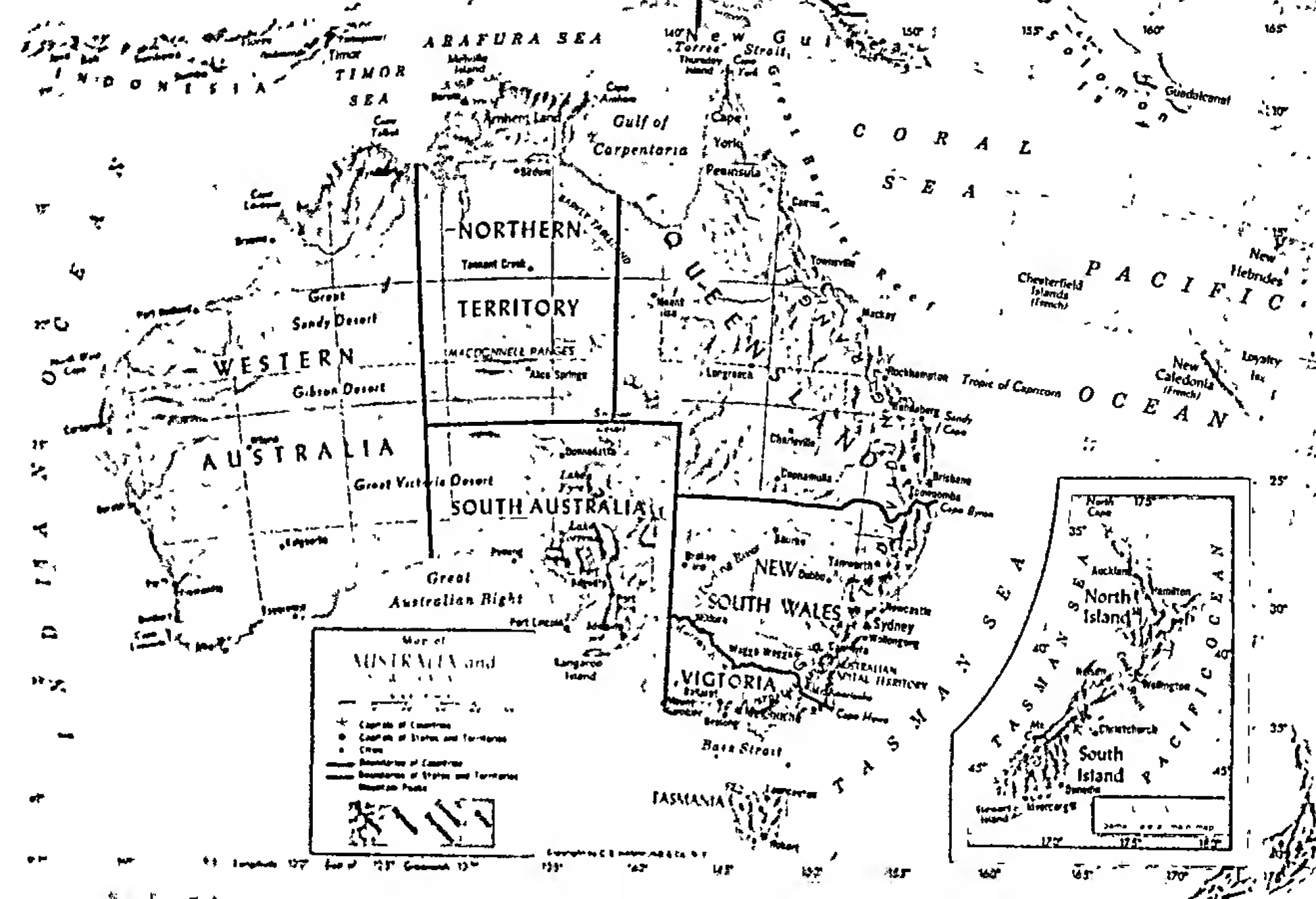
The 12,000 mile coast line of Australia is relatively smooth. There are only two large arms of the sea. In the north, the Gulf of Carpentaria lies between Yorke Peninsula and Arnhem Land. In the south, an inlet known as the Great Australian Bight lies along the middle of the coastline. However, there are several good harbors. Sidney, on the southeast coast, has great beauty along its lengthy shoreline.

CLIMATE

Australia has many CLIMATES. A rainy tropic climate is found in a small section of the northeast coast. Here the rainfall is heavy, with temperatures only moderately high. Over a greater coastal area in the north, the climate is monsoon tropical with a wet and dry season similar to the climate of most of India. The rainy season comes in November until the end of April. This is summer in Australia.

In a wide belt from the west coast to the mountains along the east is a semi-arid tropical climate. Rainfall varies from 10 to 20 inches annually, and the rainy season is much shorter than in the monsoon region to the north. Temperatures are high throughout the year, the averages ranging from about 75° to 95°F.

The great Victoria Desert occupies central and western Australia. The climate here is arid tropical. The driest parts receive less than five inches of rain a year. Parts of the desert region are named the Great Sandy Desert, the Gibson, and the Simpson. This great desert is part of uninhabited Australia and, together with some marginal lands, where only about 25,000 settlers live, constitutes at least half of Australia.


ARAFURA SEA
TIMOR SEA
INDONESIA
New Guinea
Torres Strait
Gulf of Carpentaria
Cape York Peninsula
CORAL SEA
SOLOMON ISLANDS
Guadalcanal
NORTHERN TERRITORY
Tennant Creek
MACDONNELL RANGES
Alice Springs
Great Sandy Desert
Gibson Desert
WESTERN AUSTRALIA
Great Victoria Desert
SOUTH AUSTRALIA
Great Australian Bight
Lake Eyre
QUEENSLAND
Townsville
Mackay
Rockhampton
Tropic of Capricorn
Longreach
Charleville
Brisbane
Toowoomba
Cape Byron
NEW SOUTH WALES
Sydney
Newcastle
Wollongong
Canberra
AUSTRALIAN CAPITAL TERRITORY
VICTORIA
Melbourne
Cape Howe
Bass Strait
TASMANIA
Hobart
TASMAN SEA
PACIFIC OCEAN
New Hebrides
Chesterfield Islands (French)
New Caledonia (French)
Loyalty Is.
North Island
Auckland
Hamilton
Wellington
South Island
Christchurch
Dunedin
Stewart Island
North Cape
Map of AUSTRALIA and

Cockatiel

Wombat

Australian News and Information Bureau

Common heath

Along the southern coast, toward the west and the east, a Mediterranean subtropical climate is found. Most of the rainfall is in the winter. Winters are mild although the temperature may occasionally fall below freezing. Summers are hot. Most of the east coast area of Australia has a humid subtropical climate similar to that of Florida. Rainfall is adequate and falls in every month. This is the climate in which most of the people of the country live.

One other climate is found along the coast of southeast Australia. This is the temperate marine climate similar to that of Washington and Oregon. Melbourne, in southern Victoria, Tasmania and New Zealand all have a temperate marine climate which is very mild for its latitude. Rainfall is abundant.

RIVERS AND DRAINAGE

The Murray-Darling river system is the largest drainage system in Australia. Its length is about 2,300 miles. The Murray-Darling drains the great central basin. Its waters provide irrigation and generation of electric power. Many rivers in the arid interior merely disappear in the dry soil over which they flow. Rivers along the north coast in the monsoon rainy season may be big, but in the dry season they are almost dry. The short rivers which drain the eastern slopes of the Great Dividing Range run into the Coral Sea. Those which drain the southeastern slopes run into the Tasman Sea.

PLANTS AND ANIMALS

Because Australia is so isolated from the other continents, it has many unique animals and plant forms. The laying aquatic mammal with a bill like a duck's, webbed feet, a tail like a beaver's and fur like a mole's. It provides its young with milk. It is probably a link between mammals and earlier forms in the history of EVOLUTION. The *bottle tree* is also unusual. Its trunk may hold up to 80 gallons of water during the summer.

Another famous tree native to Australia is the EUCALYPTUS. It can live and flourish in arid (dry) lands when other plants fail to survive. It sends roots down and out many times longer than its trunk. The eucalyptus has been planted for shade in arid regions of the American southwest and elsewhere with success.

Australia is best known for the KANGAROO, a member of the MARSUPIAL family. Actually, there are many types and sizes of kangaroo. The large kangaroos and wallaroos are often found in zoos around the world. The hind feet of adults measure over ten inches. The large hind legs and the long powerful tail account for the kangaroo's tendency toward an erect stance and for its ability to leap long distances. It has relatively small front feet. The WALLABY is a smaller kangaroo with hind feet which measure

Australian News and Information Bureau

The Tasmanian wolf (left), found only in Australia, is an almost extinct marsupial. The Flamingo orchids (center) are a recently discovered species. The spiny anteater (right) is a primitive mammal

from six to ten inches. A tree-climbing kangaroo is still smaller with front and hind feet almost equal in size and a less powerful tail. Kangaroos eat plants. Females carry their young in a pouch.

Another animal unique to Australia is the KOALA BEAR, a tree-climbing marsupial. It is native to the wet temperate areas of the southeast. The koala is a double for the toy "teddy bear" given to children in Europe and America. It grows to a height of slightly over two feet. The cub spends the first six months of its life in its mother's pouch. The koala eats the leaves and tender shoots of some species of the eucalyptus tree.

Native to Australia also are two strange flightless birds, the lyre and the emu. The former mimics the sounds made by other birds and animals. It spreads its tail feathers in the shape of a lyre. The emu is a large bird related to the ostrich and grows to a height of over six feet.

Australia has
ous forests
mountains
east, and
northern
the ar

erals of importance are coal, oil, zinc, silver, uranium, lead, copper and iron. Most of the wealth of Australia comes from sheep, cattle and farm products. At least one-fourth of the world's wool comes from this continent, and wheat is an important crop.

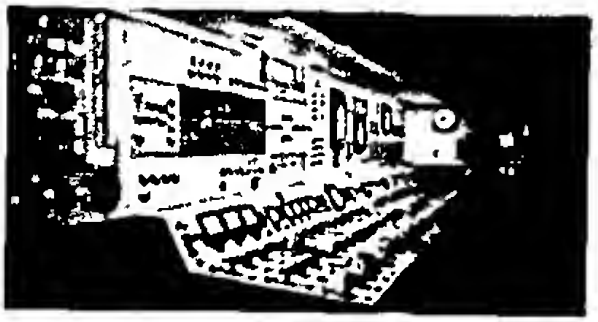
Australia has become a world leader in the production of raw materials. J. H. D.

SEE ALSO: DESERT, EARTH, GEOGRAPHY, NATURAL RESOURCES

Autogiro (otto-JY-row) An autogiro (sometimes called a *gyroplane*) is an AIRCRAFT which belongs to the rotating wing family. The craft has a body, or fuselage, somewhat like an ordinary small AIRPLANE, but it also has a large propeller (called a *rotor*) mounted horizontally, like an umbrella, overhead.

Except for the appearance of the overhead rotor, the autogiro bears little
the HELICOPTER. The rotor
on tilted back slightly and is
nected to the engine which
propeller. As the plane
forward for the take-off,
air coming under the front
blades provides a lifting
s to a stationary wing. The
starts the rotor to rotate.
rotor is power-driven only at
faster vertical lift. The rotor
ged at the rotor hub so that
rise and lower independently
change. This control action
the ability to take off and
or to ground roll. It can also
s as 20 miles per hour

pilot see Instrument
sprinkler



Inland Steel

Automatic control lets men work with ore dust that once was discarded as hazardous

Automation Automation is a way of making things or getting work done with little or no human help. Something is "automatic" if it works by itself after being started. Automation is a process within one machine or a process using many machines. The process is automated if guided by control devices which keep it moving as desired without much attention. Automation saves man much labor.

The word "automation" is relatively new. It did not appear in many dictionaries until after 1953. This word is an outgrowth of the word "automatization" which is difficult to pronounce; however, it has the same meaning Automation actually has a double meaning since it can be used to refer to both automatic operation and the process of making things automatic.

HISTORY

As early as 1784, Oliver Evans built an automatic flour mill outside Philadelphia. In 1801, Joseph Marie Jacquard built a loom which was run from a system of punched cards that became so popular that over a thousand of these machines were sold in France alone The punched card system of automatic control was not revived again until after World War II when it was recognized as a means of supplying information to large electronic COMPUTERS.

Probably one of the earliest automatic control devices was the governor on the steam engine built by JAMES WATT. This device used centrifugal force to regulate the amount of steam supplied to the driving piston. Other examples of early attempts at automation are ELI WHITNEY's cotton gin; [illegible] and the repeating rifle, designed by Henry and built by Winchester Repeating Arms Company, in Massachusetts. These inventions represent attempts at automation in three different areas. The cotton gin was one of the first semi-automatic processes in industry. The reaper was the beginning of highly mechanized farming, and the repeating rifle completely changed the tactics employed in warfare. These are all examples of individual pieces of equipment being automized.

Henry Ford is probably the one person who had the most to do with the automation of an entire manufacturing process. He revolutionized the automobile industry by his introduction of assembly line methods. Today, very few products are not built or processed by assembly line techniques.

AUTOMATIC CONTROL

Control can be as simple as flicking the switch which turns an electric light on or off, or it can be as complex as the inertial guidance systems which keep the large satellite rockets on their predetermined course.

In the driveway of a home, a light on a pole operated by a time clock in the basement is analogous to what is called *open-loop control*. Here, on and off is the only process one may wish to exercise with a control. One of the most important advantages of the open-loop system is that the control itself, which in the case of the pole light was the time clock, may be placed at a great distance from the object or machine which it controls.

There are, however, many disadvantages to the open-loop system which make the exclusive use of this system difficult in most applications of automation For instance, if the predetermined time set on the clock which controls the light is earlier than the time of sunset, it will turn the light on at that time regardless of whether the light is

Automation in a dairy provides speed and safety in handling perishable milk products

needed. In other words, there is no possible way for the time clock to tell itself not to turn the light on until the sun has set and to turn it off again when the sun rises.

Since the open-loop system has no methods of correcting errors which have been made in control, a system which could correct errors had to be devised. This particular system is called the *closed-loop* method of control. An example of a closed-loop control is the thermostat, which regulates the temperature of a room or area. Here, the only human operation which is performed is the setting of the dial. When the temperature in the room drops below the desired level, the thermostat tells the furnace that heat is needed in the area. After the furnace has sent a sufficient amount of heat, the thermostat again tells the furnace that the temperature is now at the desired level and the furnace shuts itself off. This action is unlike that of the time clock because the clock could turn the light on when it was not needed. The thermostat called for heat only when it was actually needed.

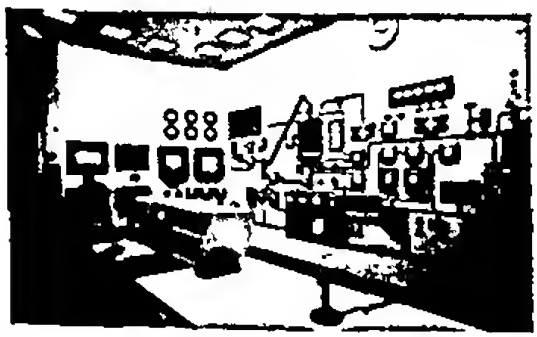
When a very efficient system of control is desired, both the open-loop and the closed-loop systems must be employed in the complete system of control. The entire process of steering an AUTOMOBILE can be considered a combination of the two systems. The steering mechanism of the car itself is an open-loop, since the wheel will turn either right or left. The driver provides the closed-loop part of the system by controlling the direction the wheels are to be turned and the amount of turning necessary.

This combined system operates somewhat in the following manner. When arriving at a turn in the road, the driver turns the wheels, steering the car around the curve. If he turns the wheel too far, his car will tend to move from the lane in which he is driving. Noticing this, he corrects the steering by turning the wheel slightly in the opposite direction, thus correcting his previous mistake. Here, the driver's eyes send out a correction signal which provides alteration and correction of the original energy output.

Another technique in control is known as *hunting* in a closed-loop control. Using the example given above, suppose that when the driver corrects his first mistake he actually corrects it too much and the car tends to leave the lane in the opposite direction. Again his eyes send out a corrective signal and once more he corrects his steering. This condition of over-correcting is known as "overshooting" or "undershooting." In certain systems, the hunting frequency can become quite large and the correction created can be more harmful than beneficial. It is for this reason that "damping" has been built into most closed-loop controls. This damping prevents immediate correction of a previous action. Such a device is incorporated into the thermostat mentioned before. To prevent the furnace from constantly being turned on and off, the thermostat allows the temperature to rise a few degrees above the set temperatures and also allows it to fall a few degrees below before actually operating the furnace. This variation from the desired value is called the *differential range* of the control.

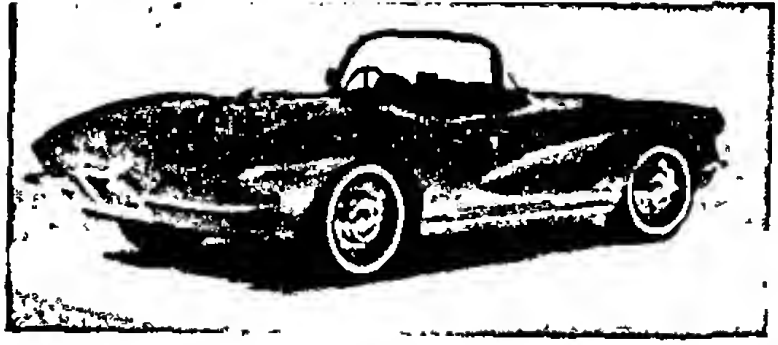
Automation is more than just automatic production. It automatically makes the decisions which man's senses would show to be necessary in altering the control of production. Electronic computers may solve problems much faster than man. These can store and recall (remember) information needed to solve the most complicated problems. Computers can also control many operations simultaneously, a task which is difficult for man.

A. E. L.

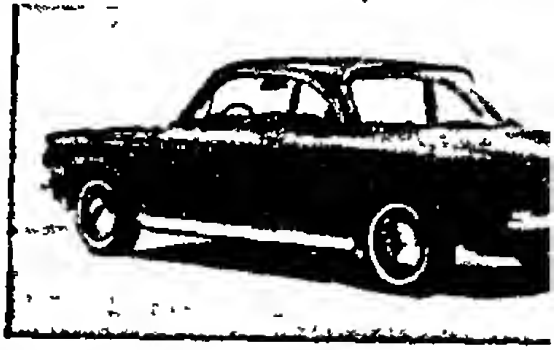


The panel at the left provides control, through automation, of all the operations in an entire steel production plant (right). Men work in safer conditions when dangerous operations are handled automatically

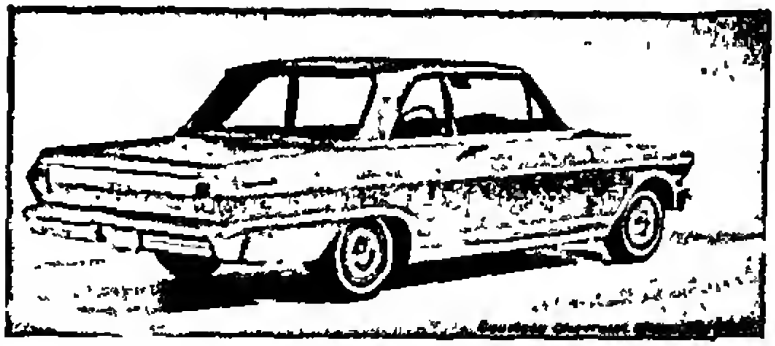
Inland Steel



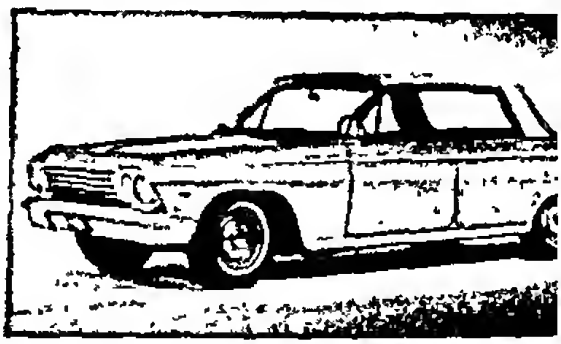
SPORTS CAR



REAR-ENGINE COMPACT



TWO-DOOR ECONOMY CAR



FOUR-DOOR SEDAN DELUXE

Automobile The automobile is a land vehicle used on streets and roads. It is also called a car or an auto. France claims the first automobile which was invented about three hundred years ago. This car had a steam engine and three wood wheels. Today automobiles use gasoline in their engines and have four rubber tire wheels. During the past seventy years, automobiles have caused more changes in daily living than any other machine. With automobiles, man can travel more widely and live farther from daily work.

The modern automobile is made up of the engine, the transmission of power to the wheels, the steering mechanism, the body and frame, the brakes, the tires, and the accessories.

THE ENGINE

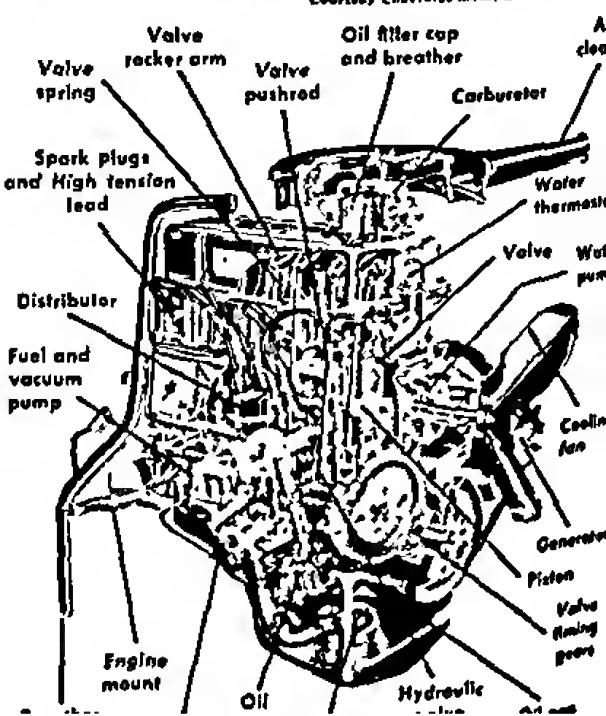
The engine is the heart of the automobile. It provides the power which turns the wheels. Its major parts are the pistons and cylinders, the connecting rod, the crankshaft, the fuel system, the ignition system, the cooling system, and the lubrication system. This type of engine is called an *internal combustion engine.*

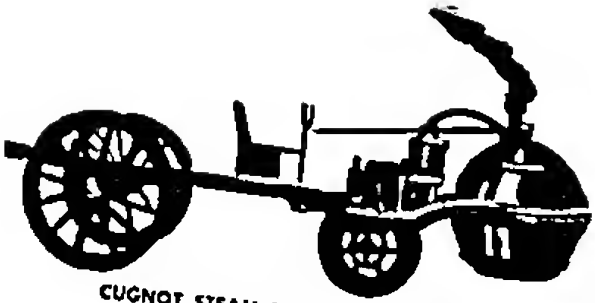
The *piston* works very much like a cannon shot from a cannon (or the *cylinder*). . the piston is pushed by the explosion fuel in the cylinder, it thrusts the *crankshaft.* Modern automobile engines have four, six, or eight pistons connected to the crankshaft. The revolving crankshaft is in turn connected to the mechanisms which rotate the wheels.

Nearly all gasoline automobiles operate on four strokes and are called *four cycle* engines. The piston moves the length of the cylinder four times to take in gas, compress the fuel mixture, burn it, and remove the waste products of the combustion

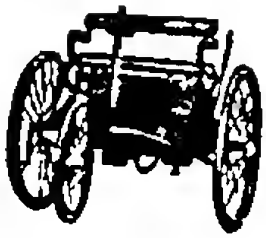
A modern automobile engine uses the latest alloys, casting and stamping techniques, and advanced engineering design to increase efficiency, durability and power

Courtesy Chevrolet Motor Division

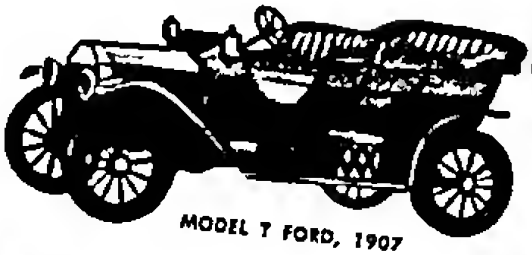




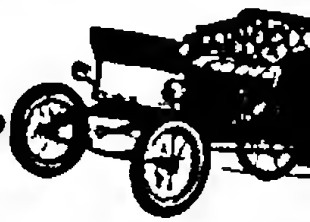
CUGNOT STEAM WAGON, 1769
FIRST STEAM AUTO



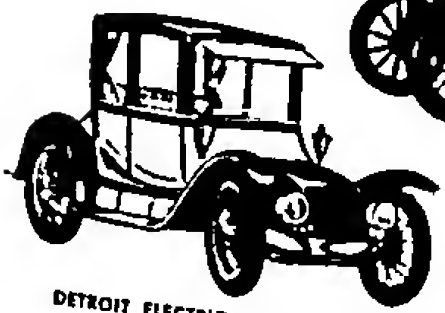
BENZ, 1885
FIRST PATENTED



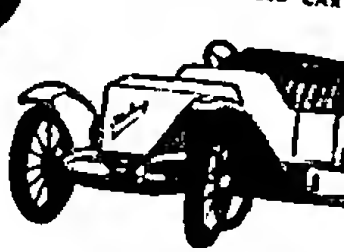
MODEL T FORD, 1907



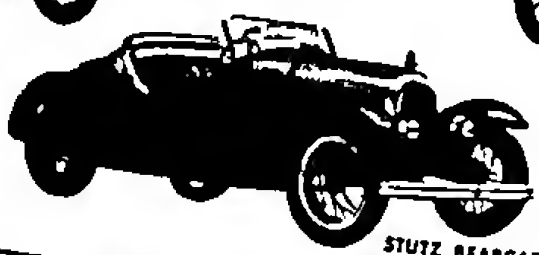
WINTON, 1898, FIRST
MASS PRODUCED CAR



DETROIT ELECTRIC, 1914

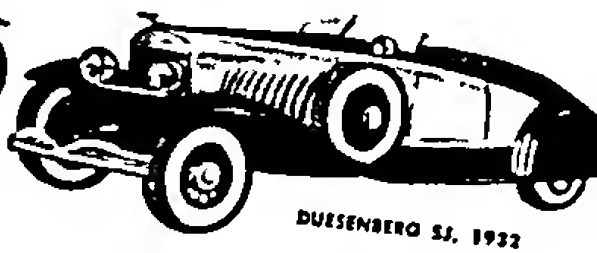


STANLEY STEAMER, 1914

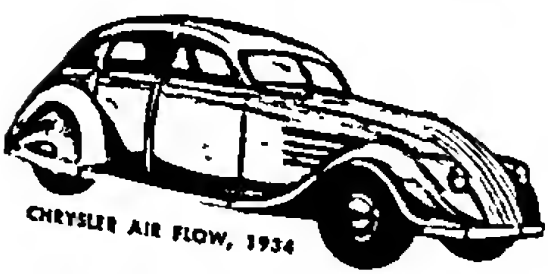


STUTZ BEARCAT, 1921

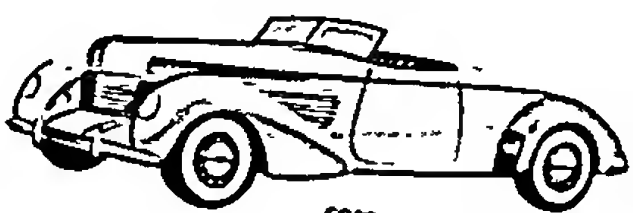
ROLLS-ROYCE PHANTOM, 1924



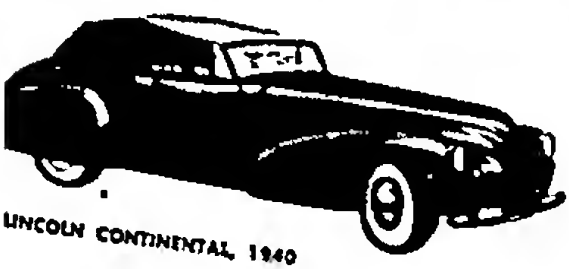
DUESENBERG SJ, 1932



CHRYSLER AIR FLOW, 1934



CORD, 1936



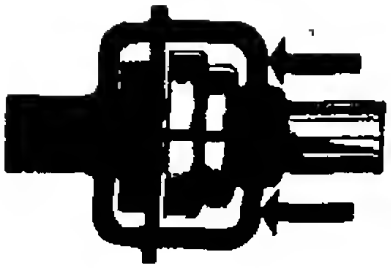
LINCOLN CONTINENTAL, 1940

through the *exhaust pipe* and the *muffler*. The entry of gasoline vapor and air into each cylinder is controlled by the *intake valve*. The waste products from each cylinder are regulated by the *exhaust valve*.

The *fuel system*, generally using gasoline, provides the explosive mixture which causes the pistons to push the connecting rods. In turn, the connecting rods compel the motion of the crankshaft. The fuel is stored inside the gasoline tank. From this tank gasoline is pumped by the *fuel pump* through connecting pipes and a filter into the *carburetor*. Inside the carburetor the gasoline is vaporized and mixed with the right proportion of air to make an explosive mixture. This explosive mixture is then drawn into the cylinder on the intake stroke.

The *ignition system* is a part of the complex electrical network. The electrical system provides the power to start the engine, to generate the electricity, to store the electricity in the battery as chemical energy, to supply the power for the electric lights, and to furnish the electric current for the ignition system. Ignition is the spark which explodes the fuel in the cylinder. The electrical current supplied by the battery and the generator is transmitted by wire to the *spark coil* and then to the *distributor*. Finally from the distributor, the current passes through the *spark plugs* into each cylinder. The high voltage necessary for the spark is provided by the spark coil. The distributor delivers the electrical energy to each cylinder at the proper time.

The *cooling system* of most automobiles uses water. Since the constant explosion of gas at more than 3500° Fahrenheit would soon damage the car, circulating water is used to keep the surface temperatures as low as 160°F. The water is moved by a special pump through hollow channels (*water jackets*) surrounding the cylinders. From there, the heated water circulates to the radiator by connecting hoses. In its passage through the honeycomb cells of the radiator, it is cooled with outside air pulled in by a fan operating directly behind the radiator. The cooled water then recirculates to the engine's water jackets. THERMOSTATS open and close the water passages so as to keep the water and engine parts at the best operating temperatures. In winter, a mixture of water and an ANTIFREEZE is used to prevent damage from freezing



Courtesy Chevrolet Motor Division

A friction clutch operates with a force applied in the direction of the arrows when it is engaged by pressure on the foot pedal. When disengaged, the force is removed and the friction disc moves opposite the arrows

The *lubrication system* reduces friction by distributing oil from the reservoir in the *crankcase* to the bearings, to the crankshaft, to the pistons, and to the other moving parts. The *oil pump* sends oil through pipes to these friction points. The movement of the engine parts also splashes oil onto the moving components. A lighter weight oil is used in cold weather than is used in summer to allow easier engine starting. "All weather" oils are replacing the older practice of using a light oil in colder weather and a heavier oil in warm weather.

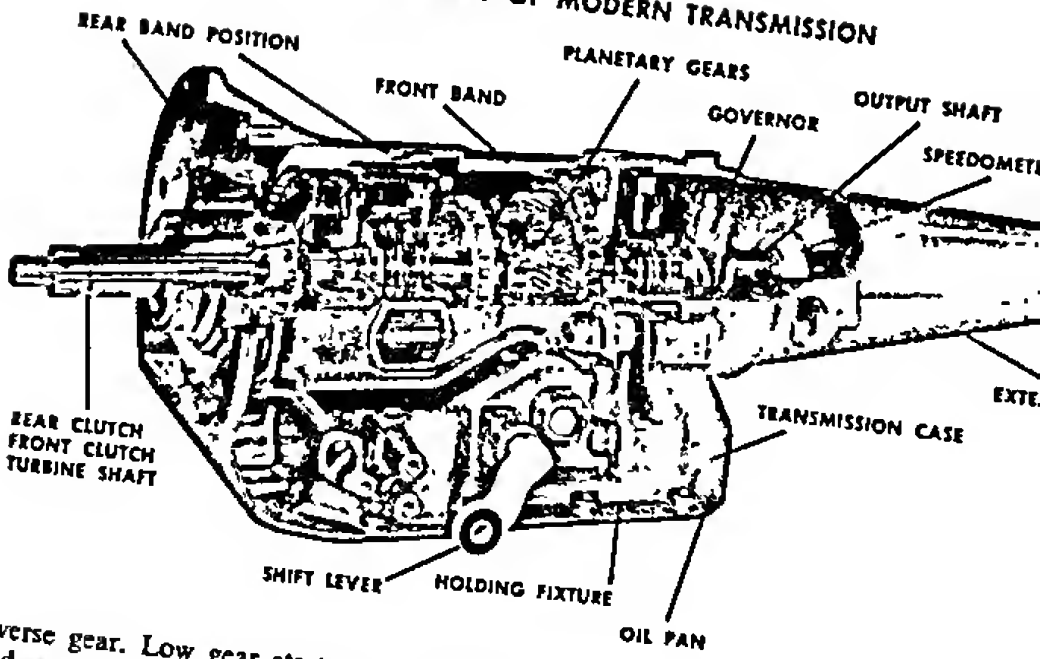
TRANSMISSION

The engine power is transmitted to the wheels through the *clutch*, the *transmission*, the *drive shaft*, and the *differential*. These parts are called the *drive train*. Most automobiles utilize the rear wheels as drive wheels, but some European models use front wheel drive. A few automobiles have a four wheel drive.

The *friction clutch* connects the drive train to the crankshaft of the engine. A clutch has metal plates which are held apart when the driver, while shifting gears, pushes down on the clutch pedal. When the driver "lets out" the clutch, the plates press together tightly and gradually turn the rear wheels. In *fluid clutches* no mechanical connection exists between the plates, as the power is transmitted by whirling oil.

The *manual transmission* is directly behind the clutch on most automobiles. The transmission contains gears of different sizes. In some cars the driver uses the gear-shift lever to select the proper forward or

CUTAWAY OF MODERN TRANSMISSION



reverse gear. Low gear starts the car, second gear picks up speed, and high gear maintains normal driving. In reverse gear the *drive shaft* turns in the opposite direction from the crankshaft. Many modern automobiles have an automatic transmission replacing the friction clutch and the manual transmission. In the automatic transmission the gears are shifted automatically when the engine reaches certain speeds. This feature establishes much easier driving

The *drive shaft* carries the power from the transmission to the differential. The drive shaft is connected to the transmission and the differential by one or two *universal joints*. The universal joint, or flexible coupling, enables the transmission to be rigidly mounted to the engine and allows the rear axle to move up and down as the automobile rides over bumps. Some automobile manufacturers have moved the transmission to the rear of the drive shaft to eliminate the hump in the center of the floor.

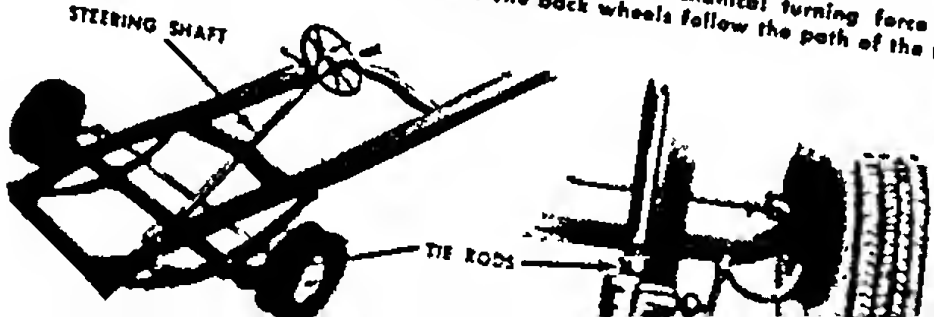
The *differential* allows the engine's power to turn the rear wheels When the mobile turns a corner, the differential the wheels on the outside to rotate than the wheels on the inside If one at the rear axles of a car, an oval-sh housing at the center of the axles wi seen This case holds the differential ge One disadvantage of the differential is action when wheels slip on ice If one wheel slips, that wheel will spin rapi while the other rear wheel will stand st Many of the newer cars can be equipp with a positive traction device to overcon this difficulty.

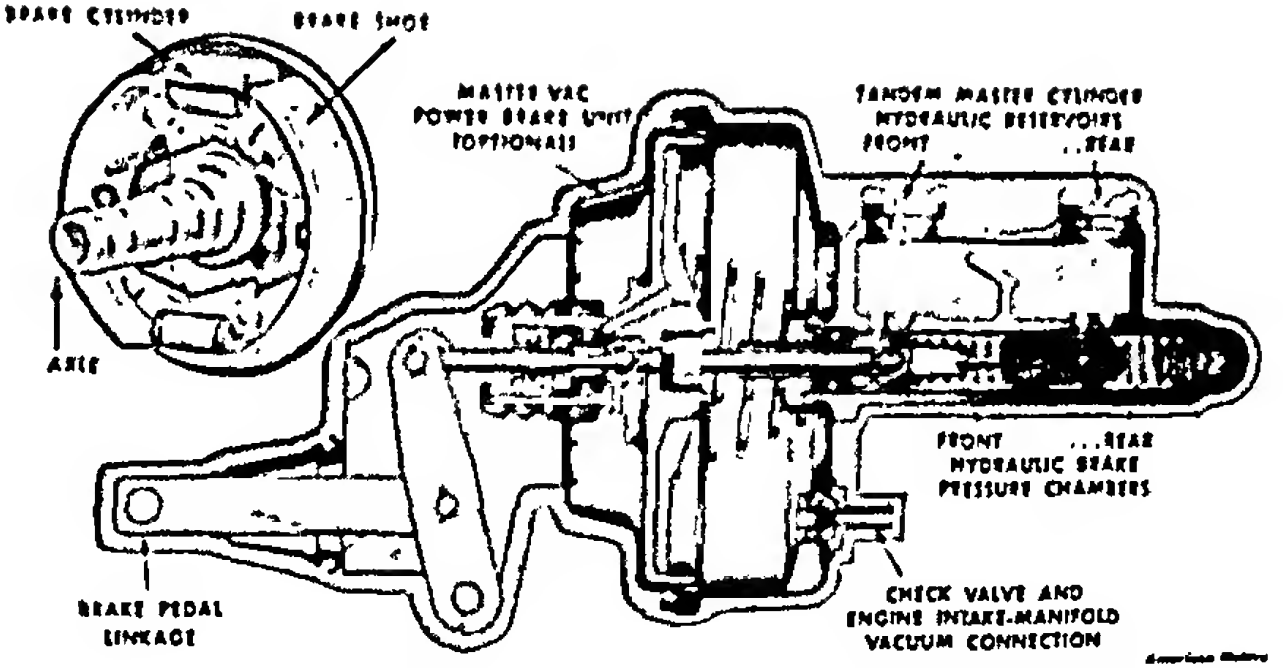
STEERING SYSTEM

A series of gears, rods, and shafts con verts the circular motion of the steering wheel to the sideways motion which is required to turn the wheels for steering

Since the force needed to turn heavy wheels is considerable, more and more manufacturers are easing the driver's burden by applying hydraulic force ("power steering") to the steering mechanism

The steering shaft allows the steering wheel motion to exert mechanical turning force upon the front wheels, through the movement of tie rods. The back wheels follow the path of the front ones





BRAKE SYSTEM

Those who have held their heel against the wheel of a scooter will have an idea of the principle of automobile brakes. A metal cylinder is attached to each wheel. Around this cylinder, a heavy material called the *shoe* is held so that it does not quite touch the cylinder. Movement of the brake pedal makes all of the shoes press against the cylinders. The wheels stop, slowly or quickly, depending on the amount of pressure.

Braking used to depend entirely on mechanical force, but now a hydraulic system is used. In addition, many drivers now use power brakes. These use engine force to supplement the driver's foot power.

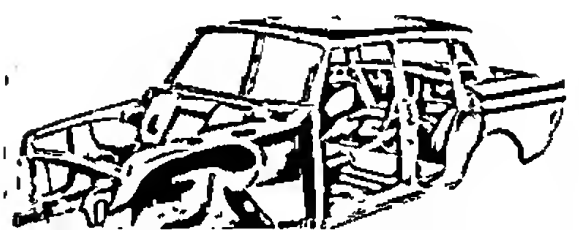
BODY

Automobile *bodies* have undergone many changes. Streamlining to wind resistance is one of the engineer's chief concerns. Many modern steel automobile bodies are of a single body and frame construction known as *unit construction.* Traditionally, automobiles have had separate bodies and frames. Some fiber glass and plastic automotive bodies are now being manufactured.

The *suspension system* consists of coil, or leaf springs, and shock absorbers placed between the frame and the wheels. This location affords protection from road shock to the car and to the passengers. Some automobiles use *torsion bars* or *air suspension* instead of the metal springs.

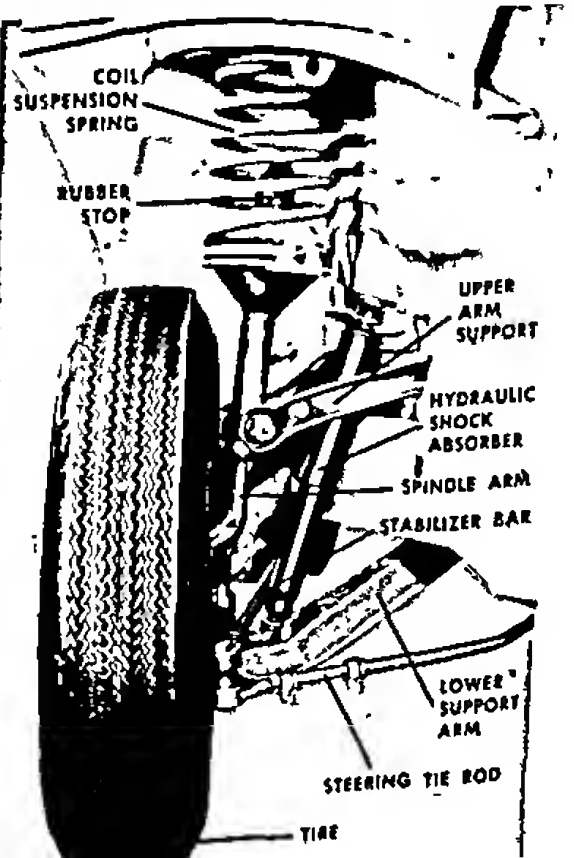
A modern auto body is made in a one-piece, stressed steel unit to increase strength

American Motors



A typical automobile front wheel suspension

American Motors



HISTORY

Steam as the source of power for an automobile was first used in 1769 by Nicolas Cugnot of France. In the early nineteenth century British, French, and American inventors built a variety of steam automobiles. Their successes were hampered by poor roads and by laws enacted to eliminate the noise and smoke of these autos. The most famous American steam automobiles were the Stanley Steamers, which were manufactured until 1925.

The gasoline automobile, as it is known today, was first invented in the early 1890's by the Frenchmen René Panhard and Emile Levassor. The Duryea brothers constructed the first gasoline auto in the United States in 1893.

The future of automobiles promises many changes and innovations Compact cars introduced during the late 1950's appeal to many Americans. The AIR-CUSHION VEHICLE, riding on a cushion of air rather than on wheels, may be the car of the future. Gasoline TURBINE engines are in the developmental stage. Invented in Germany, the *Wankel rotary* engine presents a new concept in engine design. P. F. D.

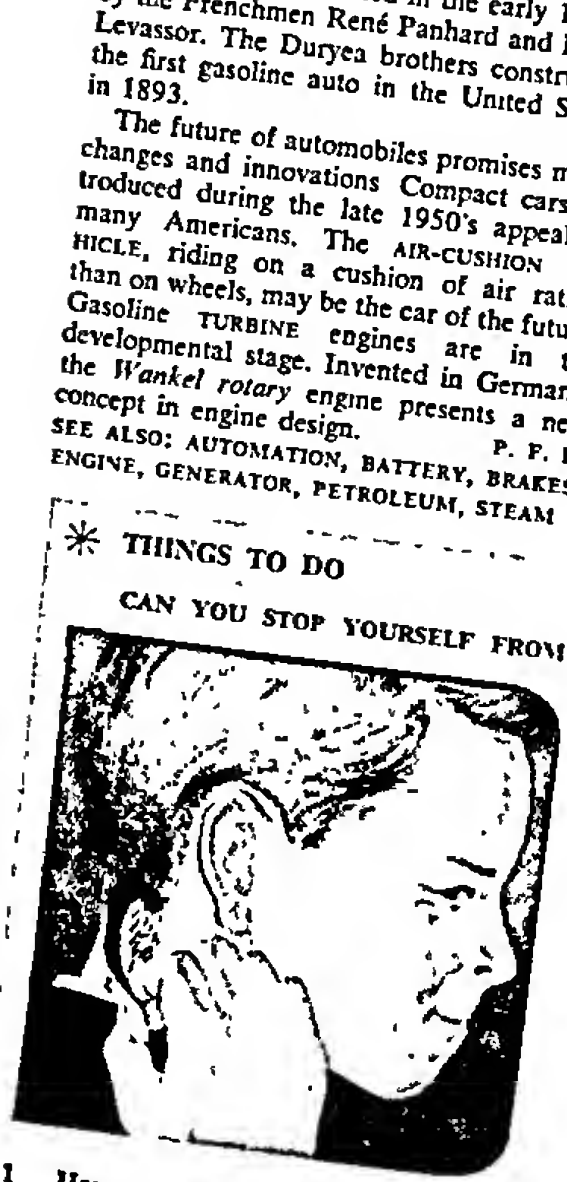
SEE ALSO: AUTOMATION, BATTERY, BRAKES, ENGINE, GENERATOR, PETROLEUM, STEAM

Autonomic nervous system
boy goes to school he may
or slow, sometimes he run
cides at what speed he wi
uses his legs to walk and
carry books. These actions
trolled by decision. There a
things about people that they
control consciously. They ca
trol heart beat. Sometimes i
fast and at other times it beats
They have difficulty controllin
breathing. Actions over which
have no voluntary control are c
out automatically by the auto
nervous system.

Along with the control of the rate
heart beat and breathing, the auto
nervous system governs the contracti
smooth muscles in the skin, digestive
the blood vessels, the bladder and
bronchi of the lungs It also controls
secretion of various glands The autono
system is itself governed by the re
centers of the central NERVOUS SYST
and does not function independently.

✳ THINGS TO DO

CAN YOU STOP YOURSELF FROM DOING THESE ACTIONS?



1 Have someone tickle the back of your neck with a feather. Can you stop from having "goose pimples?"

2 When you are embarrassed keep yourself from blushing. Don't permit the blood vessels to dilate in your face which causes the flushed appearance.

3 Cross your legs and sit relaxed. Have someone tap your leg just below the knee when you are not watching. Can you keep your foot from kicking out?

4 As you get a strong impulse to sneeze, try to stop it. Do not touch your nose with your hand.

5 All of these responses are reflexes controlled by the autonomic nervous system. They are done automatically and usually out of our control. C
you see the

The autonomic nervous system is divided into two parts: the *sympathetic* division and the *parasympathetic* division. They are basically alike in cellular structure, consisting of bead-like *ganglia* which make connections with the central nervous system and also send out fibers to various parts of the body. These fibers leaving the ganglia differ from ordinary nervous fibers, for they are not covered with a *myelin sheath*. There is always a chain of at least two neurons between the nerve cord and the end organ.

However, the two divisions are located in different areas and are opposite in their action. The parasympathetic system is located in two parts of the body; in the brain (midbrain and medulla) and in the sacral region of the spine. The sympathetic system extends along the thoracic and lumbar regions of the spinal cord. The ganglia are arranged in pairs on each side of the vertebral column.

The autonomic nervous system functions to maintain an internal balance within the various organs of the body. Nerve fibers from both the sympathetic and parasympathetic system affect the same organ. They are opposite in their effect upon the organ. For example, the parasympathetic nerves slow the heart beat; the sympathetic sends impulses to accelerate it. The parasympathetic system causes secretion of the salivary glands, whereas the sympathetic inhibits secretion. Impulses from the parasympathetic cause contraction of the pupil of the eye while the sympathetic sends impulses to dilate the pupil. The behavior of any organ which is controlled by the autonomic nervous system is the net result of the opposing impulses of the parasympathetic and the sympathetic divisions.

The autonomic nervous system releases hormones from its nerve endings. The neurohormones of the sympathetic system are identical in action with adrenalin and parasympathetic nerve endings release acetylcholine.

The overall effect of the autonomic nervous system and its companion, and ADRENAL GLAND, is to prepare the body to meet situations which present a threat to its normal functioning. The sympathetic system prepares the body for action; the parasympathetic system saves the resources of the body. G. A. D.

SEE ALSO: NERVE CELL, SPINAL CORD

Autotomy (awh-TOTE-uh-me) Autotomy is a process in which an animal destroys certain parts of its body in order to escape capture by other animals.

This process is termed *self-mutilation*. Through the presence of special modifications at the base of the appendage or limbs, some insects and crustaceans are able to drop these appendages off when another animal seizes them. Some examples of these are the claws of the CRAYFISH, the arms of a STARFISH, and the tails of some lizards.

Autotomy may be followed by *regeneration*, which is the process by which some animals are able to grow new parts of their bodies when old parts are torn off. V. V. N.

SEE ALSO: ANIMAL, CRUSTACEA, INSECTA, REGENERATION

Autumn see Seasons

Autumnal equinox The autumnal equinox is the start of autumn. It occurs about September 22 in the northern hemisphere. On this date, DAY AND NIGHT are of equal length and the sun is shining at both poles.

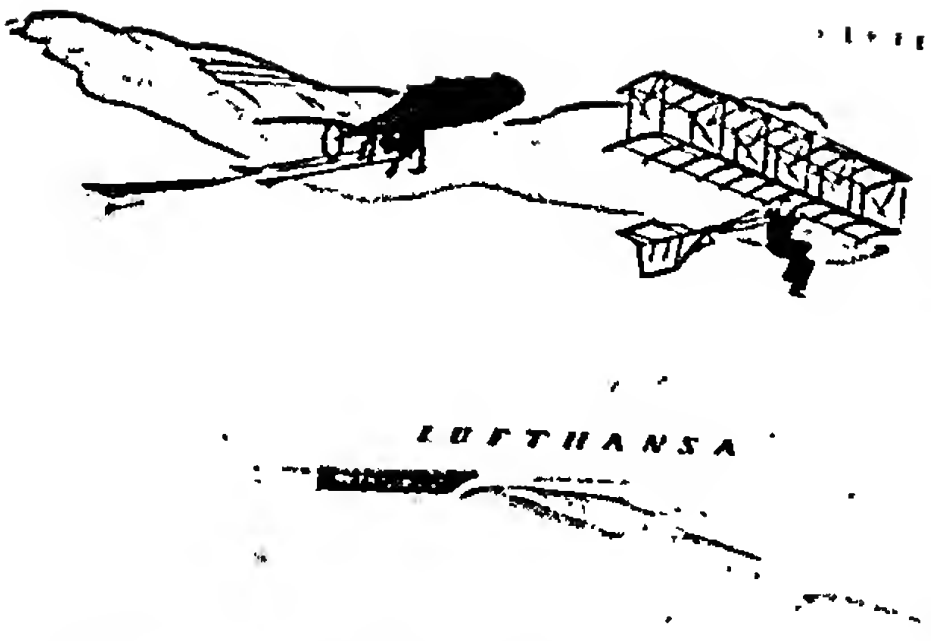
SEE: EQUINOX, SEASONS

Auxin see Hormones, plant

Avalanche Mountain sides or sloping cliffs may be covered with snow. When the snow is heavy it may begin to slide. This sliding snow is called an *avalanche*. Sometimes this sliding starts when there is a heavy wind or melting. Even small motions can start an avalanche. When the slide goes, it may move slowly or as fast as 100 miles an hour. Sometimes the avalanche will do great damage. Sliding rocks and earth is called a *landslide*.

An avalanche will not take place if the angle of the slope against the ground is less than 25 degrees. If the slant is greater than 35 degrees, and if there is a foot of new snow present, an avalanche is likely to occur. Slab avalanches of wind-packed snow are very hazardous. D. E. Z.

Aves see Birds



707 Jet airliner carrying more than one hundred passengers

Aviation Aviation is a term used to include all of man's activities concerned with flight through the ATMOSPHERE. This means aircraft manufacturing, commercial and private flying, as well as all related and supporting activities. A new term, *Aerospace*, is frequently used in place of *aviation*, as it includes man's flight beyond the atmosphere into space.

Aviation, as a mode of transportation, has made a great impact upon human life. It has enabled man to become independent of geographical barriers and to travel swiftly over great distances. Rapid changes in social, political and economic traditions of the world have been brought about. Aviation has had a tremendous influence on international affairs and military concepts.

EARLY HISTORY

The beginning of aviation is lost in the dim legends of man which tell of flying gods and heroes. The first scientific approach to the problems of flight was made by LEONARDO DA VINCI, of Italy, several hundred years ago. His designs for man-powered flapping wings, HELICOPTERS and PARACHUTES were remarkably far-seeing, yet he had no suitable powerplant, and flew only models of his designs.

For centuries and in many countries, man continued the search for the secrets of flight. Observing the flig
vealed valuable knowledge,
curved surface of the wing
vantage of launching into
efforts failed to successfully
ornithopter to imitate bird's f

The *Montgolfier* brothers
served the rising action of w
experimented with cloth,
balloons. Man's first successfu
the atmosphere took place ir
neath one of these BALLOONS
gas soon replaced hot air, mak
extended flights Another French
Giffard, solved the major proble
ing flight in 1852 by building a
or cigar-shaped DIRIGIBLE balloon
propelled forward by a lightwe
engine connected to a propeller

Although successful flight was
with lighter-than-air craft, experim
tinued with heavier-than-air cra
in the 1800's *Sir George Cayley* of
presented his belief that the sol
flight lay in a fixed curved wing
than the flapping type and that
craft should be driven with me
power The knowledge Cayley contrib
the science of flight from his glider
ments was so valuable that he has b
known as the "father of aeronautics"

Successful glider flights and othe
periments by the German Otto Lil
and the Americans Octave Chanute,
Montgomery and Samuel Langley, ar
the serious interest of the Wright Bro
in aircraft flight. ORVILLE AND WI
WRIGHT scientifically collected as
data as was available

tions. This resulted in the design and perfection of a highly successful glider in 1902 which could be easily controlled in flight. The Wright brothers next developed a suitable light weight engine and effective propeller which were added to their glider. Mythological dreams became a scientific reality on December 17, 1903, as Orville Wright made the first successful powered flight of 12 seconds duration at Kitty Hawk, North Carolina.

WORLD WAR I AVIATION

The pressure of the First World War brought the airplane out of its infancy into practical use as a weapon. At first, aerial reconnaissance was the primary role of the airplane. As the information brought back by flying scouts became increasingly important to the success of the ground armies, the pursuit plane, with machine guns, was developed to destroy enemy scouts.

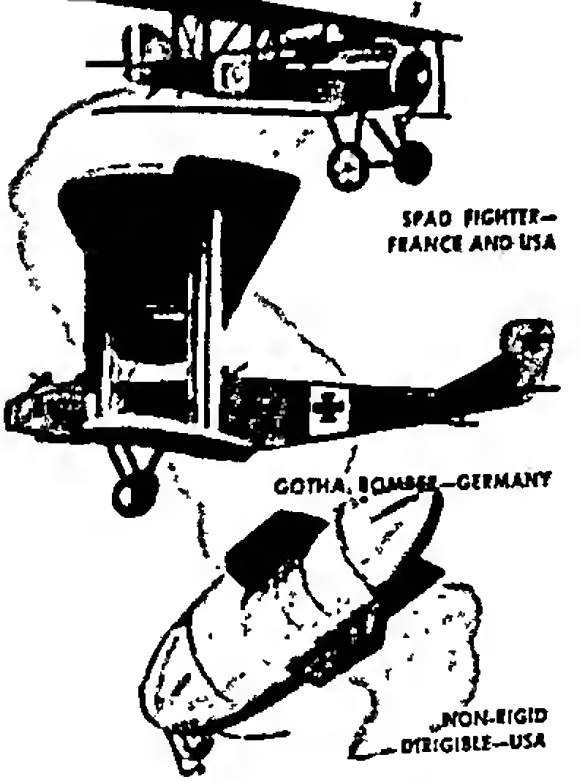
Aerial combat was born as the scout airplanes became armed and the aircraft battled each other for control of the sky. Aircraft were developed to attack enemy ground forces with machine guns and crude bombs. Large scale efforts to develop and construct superior aircraft were expended by the opposing governments, providing the impetus for the establishment of a real aircraft manufacturing industry.

POST WORLD WAR I AVIATION

At the end of World War I, surplus military aircraft were sold to former military pilots and soon "barnstormers" were introducing aviation throughout the country. Aircraft and engine improvements continued. Now speed and altitude records were constantly being set, oceans were spanned and round-the-world flights accomplished.

The Atlantic Ocean was conquered in 1919 by U.S. Navy airmen flying in the Curtiss flying boat NC-4. The organization of official government committees and services provided a stimulus for the aviation industry. A young American, CHARLES A. LINDBERGH, electrified the world in 1927 by flying solo non-stop between New York and Paris. A surge of enthusiasm for fly- followed this feat and brought about new support to the infant aviation industry.

In the 1930's the air transport industry



took root and began to grow. Airway facilities became adequate for scheduled flight operations. Airlines themselves advanced from converted military biplanes to all-metal, trimotor and twin-engined monoplanes. The famous Ford Trimotor and Douglas D.C. series of airplanes became familiar sights to air travelers.

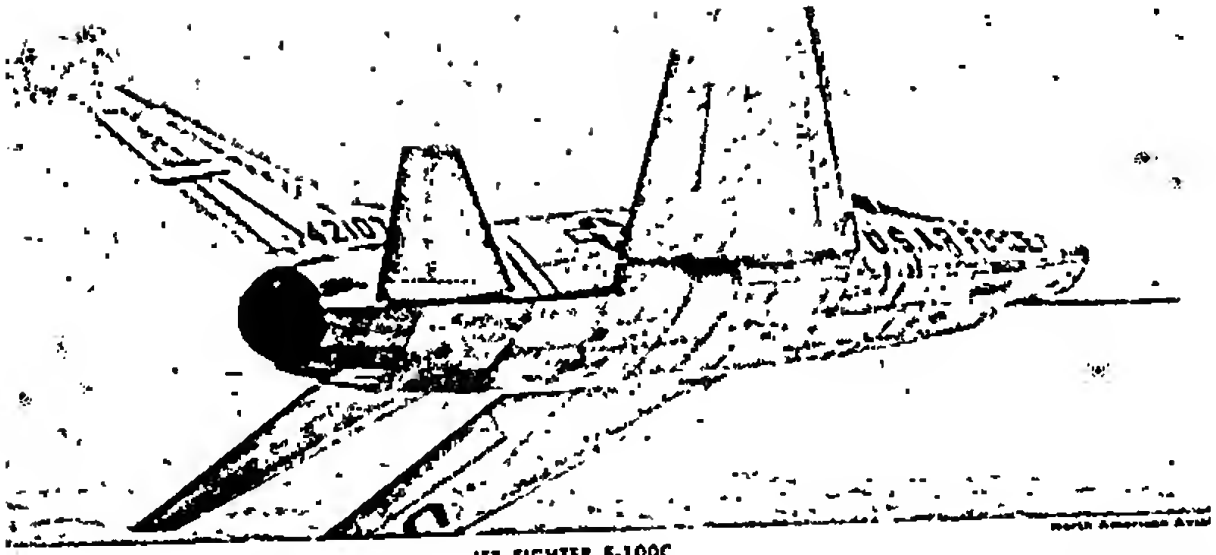
WORLD WAR II AVIATION

Aviation made great advances during World War II. The manufacturing industry expanded to produce over 200,000 aircraft. Accelerated research made possible more powerful engines, new materials, faster and larger aircraft, new electronics and communications equipment, and countless other technological developments which would have perhaps taken decades to bring about in peaceful times. As military aircraft in World War I were an auxiliary aid to the ground forces, World War II air power became a striking force in its own right.

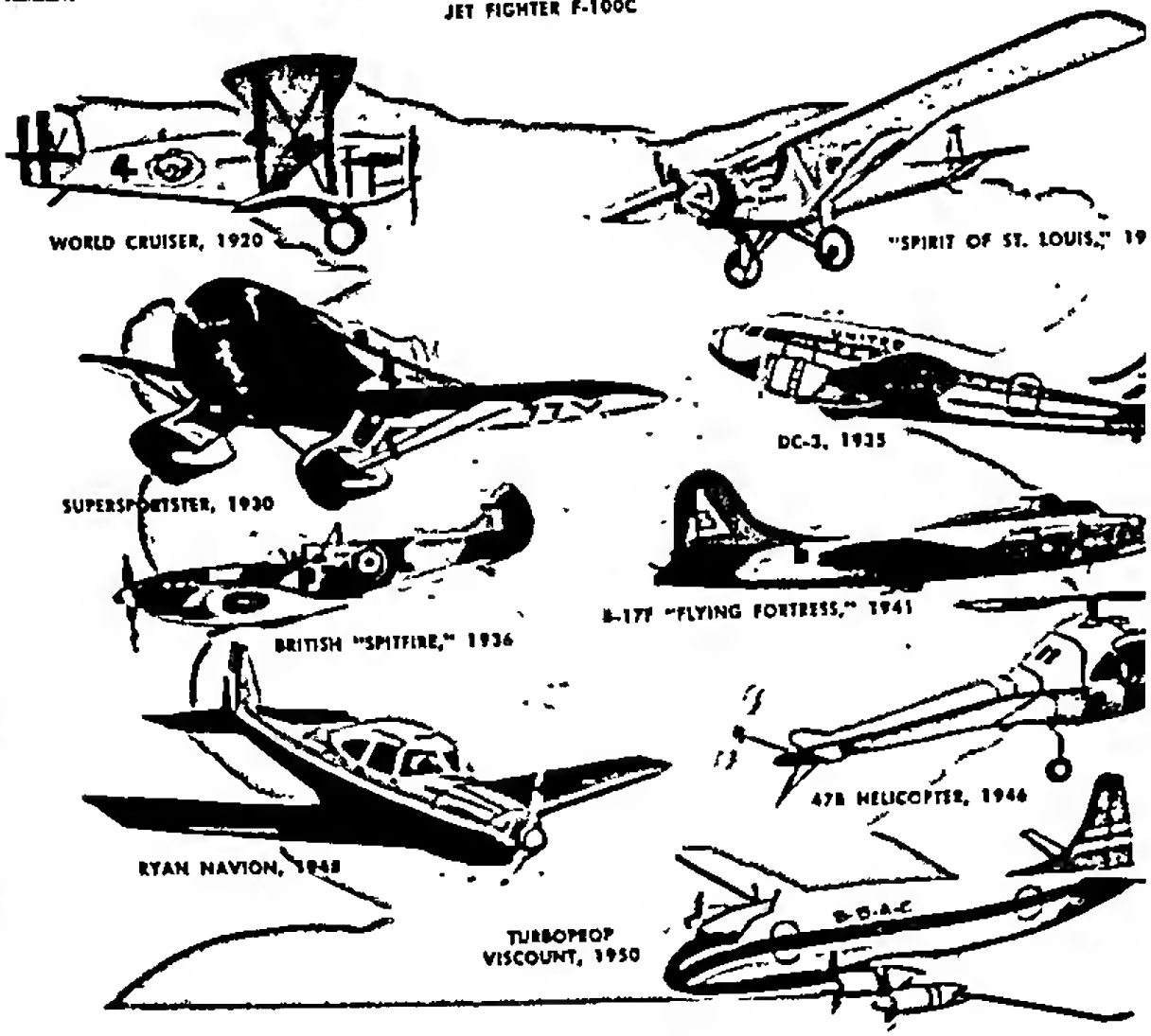
The *turbojet* engine was developed early in World War II, but did not receive wide scale use until after the war. This powerplant is characterized by its light weight, simplicity of operation and ability to deliver tremendous power at high speeds and altitudes. It is ideally suited for aircraft use and has made possible today's high performance jet aircraft.

AVIATION TODAY

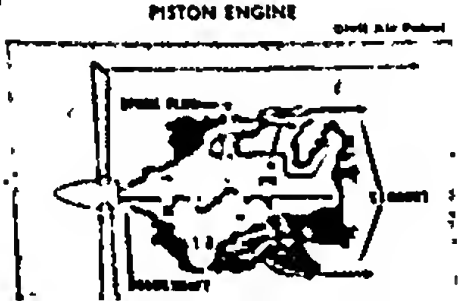
The aviation manufacturing indus-



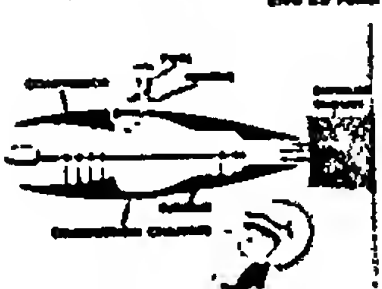
JET FIGHTER F-100C



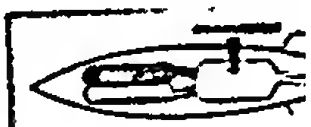
PISTON ENGINE

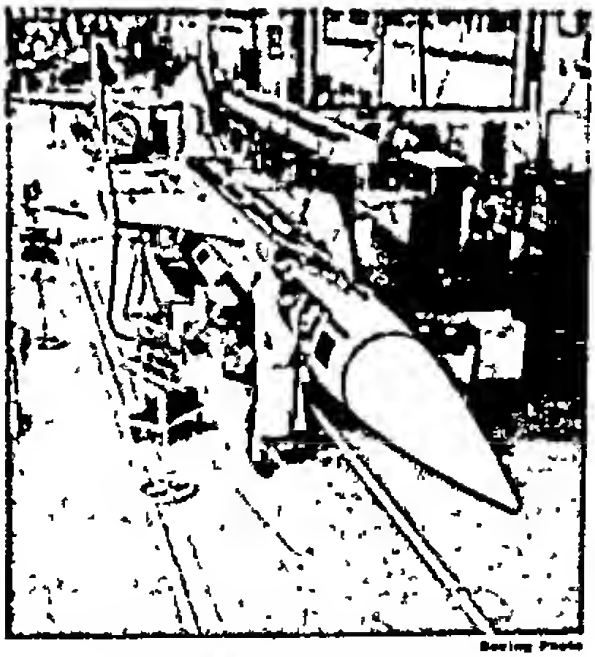


PURE JET ENGINE



ROCKET ENGI





Bomarc IM99 missile assembly line

try has grown greatly in the last twenty years. Production during the war reached 50,000 planes a year. This was more than the industry had produced in its entire history up to the war. Today's manufacture of high performance aircraft, missiles and related space vehicles is a staggering undertaking. Tiny, delicate work can be done with mass production techniques. The industry employs numerous scientists, engineers, and skilled technicians to design, test and maintain production. Over 20,000 skills are now required by the industry, with many new technical career fields coming into existence each year.

The air transport industry continued to grow. Almost half of commercial travel today is by air transportation. Jet airliners became possible in 1959. These giants carry over 100 passengers at over 600 miles per hour, using the advantages of high altitude flight. In 1960, 721 American cities were served by the airlines. The lines carried nearly 58 million passengers and huge amounts of mail and freight. Nearly 170,000 people are employed by the airlines today as compared with only 13,000 in 1939.

Airports are a vital and indispensable part of aviation. Today there are about 7000 airports of all types in the United States. The modern airport must be able to provide refueling, maintenance, weather and other information pertinent to flight, in addition to the numerous other services required. Jet airliners now often require runways over two miles in length, built strongly enough to support their heavy weight.

There are many kinds of flying other than military and scheduled air transportation. They are business flying by private firms, professional men, farmers and ranchers; flight instruction; commercial agricultural flying; pleasure flying and other miscellaneous aerial operations. Together, these activities are called *general aviation*, which now operates approximately 80,000 aircraft and accounts for almost half of all the hours flown today.

United States military aviation utilized approximately 33,000 aircraft in 1960. The *Air Force* is charged with three major missions in the defense of the nation—to defend the United States against air attack, to deliver a counterattack against an aggressor, and to give support to the army and navy in their operations. High performance jet bombers and fighters as well as transports and other aircraft are constantly under development to improve the USAF's capability. Technological advances are adding the guided and ballistic missiles to the Air Force inventory of military weapons.

Naval aviation has the task of gaining and keeping control of the air in support of fleet operations. It is considered as a tactical weapon and part of the fleet, just as the submarines and amphibious forces are. Navy combat aircraft are designed to operate from aircraft carriers and in addition to being constructed to withstand the shock of catapulted launchings and arrested landings, frequently have wings which fold to permit easy storage on the carriers' hangar deck. *Marine aviation* employs fighters and bombers to assist the Fleet Marine force in its amphibious operations.

GOVERNMENT CONTROL AND REGULATION

The federal government regulates the use of the nation's air space through two agencies: the *Federal Aviation Agency* (FAA), established in 1958 to replace the *Civil Aeronautics Administration* (CAA), and the *Civil Aeronautics Board* (CAB). The FAA is responsible for the safety and progress of aviation in this country. It supervises and controls both civilian and military use of the air. Five major bureaus of the FAA carry out its various programs.

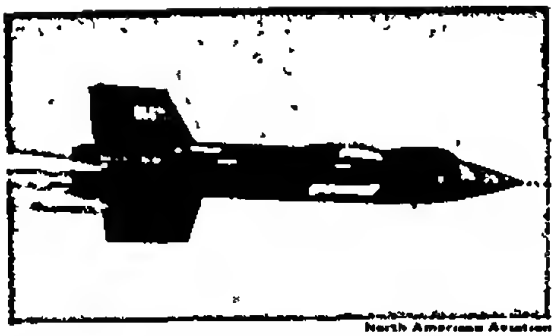
The *Bureau of Research and Development* develops and tests new equipment and procedures required for safe and efficient air traffic control. It recommends new regulations to the FAA administrator on the basis of these tests. The *Bureau of Flight Standards* establishes and enforces regulations, and is responsible for certifying the airworthiness of aircraft and the flight competency of pilots, engineers and navigators. The *Bureau of Air Traffic Management* has the responsibility of keeping aircraft safely separated while operating in controlled space on the ground and in the air. An extensive system of RADAR and radio communications is employed. Flight service through ground-air communications provides the pilot with en-route flight information such as weather briefings.

The *Civil Aeronautics Board* was created in 1938 and today functions as an independent five-man body responsible for the economic regulation of commercial air transportation including the awarding of routes and establishing air mail rates.

RESEARCH AND DEVELOPMENT

The advance of aerospace technology depends upon a foundation of continuing scientific research and development activities. This is a threefold, inter-related activity, consisting of *basic research* (seeking knowledge, not mechanical devices), *applied research* (finding uses for the knowledge), and *development* (building a model or developing a technique).

The urgency to advance military aerospace capability has brought about the channeling of facilities and huge allocations of funds into aerospace research and development. Technical break-throughs in making available new materials, air vehicle designs, more powerful engines and fuels, have resulted in impressive new aircraft and missiles. Of prime significance has been the growth of the ELECTRONICS industry. Miniaturized computers, electronic instruments, communications equipment and countless other components have made possible remarkable guidance, control and operation of highspeed aircraft and missiles.



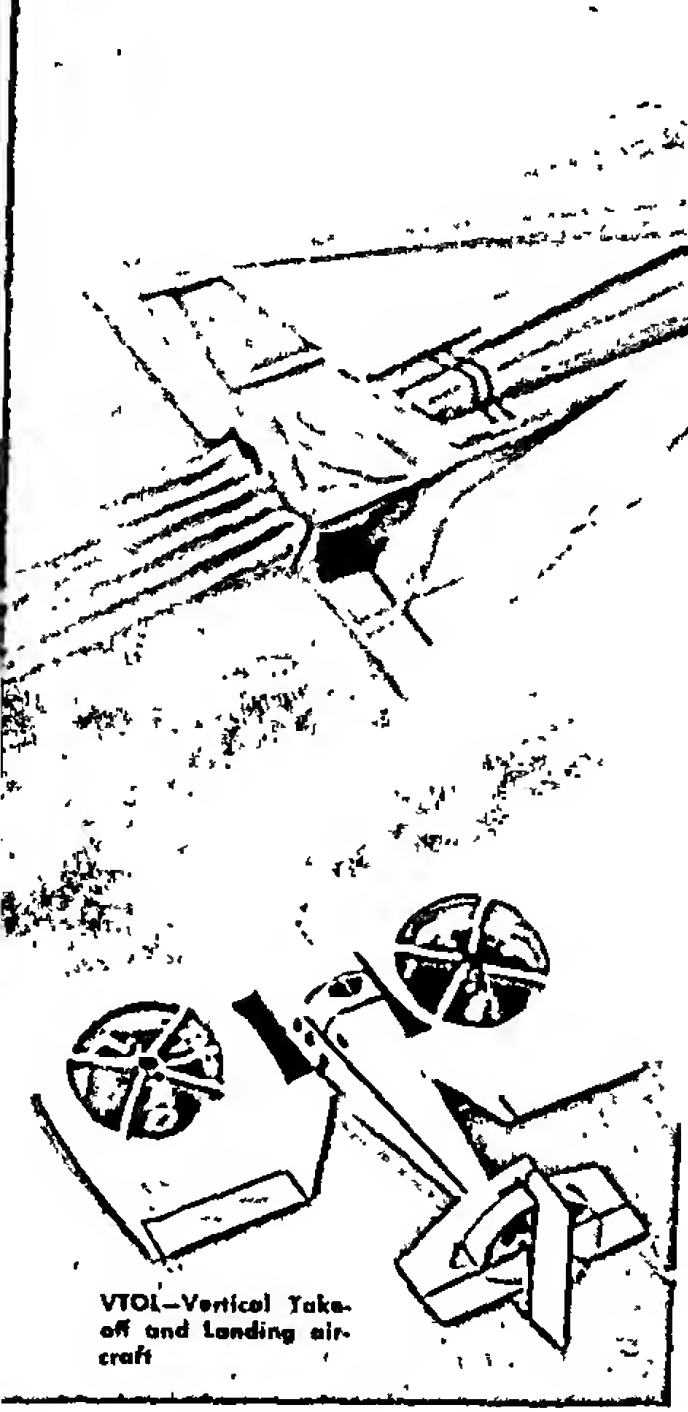
X-15 rocket plane, aircraft with rocket engine that broke all speed records in October, 1961

Although the initial purpose of the aerospace research and development activities is primarily to satisfy the needs of the military, most of the developments are eventually reflected in some form of civilian manufacturing and processing.

The *National Aeronautics and Space Agency* (NASA) was formed by the federal government to direct this country's peaceful exploration of air and space. The pioneering Mercury man-in-space project, communications, weather and other satellites are programs currently being conducted by NASA. More advanced programs, such as the Surveyor project, which will explore the surface of the moon, are now under way. The knowledge gained by NASA is made available to the aviation industry and the military as well as shared with the rest of the scientific world.

AVIATION TOMORROW

The future of aviation lies in the constant improvement of means of travel through the atmosphere and through the SPACE beyond. The growing problems of air traffic control and over-crowded air space are serious and must be solved by the miracles of electronics if flights are to be made in safety. Within a decade commercial transports are predicted which will fly at speeds in excess of 2,000 miles per hour, automatically controlled by electronic com-



VTOL—Vertical Take-off and Landing aircraft

puters, and flying near the fringes of space. Aircraft which will climb and descend vertically from very small landing areas will serve metropolitan areas.

The desire of the private citizen for personal air transportation may also be met with new developments which will permit safe, fast, light aircraft so share the sky with the rising number of high performance commercial and military aircraft. R. J. J.

SEE ALSO: AERODYNAMICS; AERONAUTICS; AIRCRAFT; AIRPLANE; AIRSHIP; ASTRONAUTICS; FLIGHT, PRINCIPLES OF; INSTRUMENT LANDING SYSTEM; INSTRUMENT PANEL; JET PROPULSION; ROCKET ENGINE; SPACE TRAVEL; SPACE VEHICLES

Avocado (av-uh-KAH-doh) Avocado is an evergreen tree and the fruit that grows on it. It is also called *alligator pear*. It belongs to the LAUREL family. It grows in California, Florida, southern Mexico and Central America.

The tree will grow to 50 feet tall in the wild state. In orchards, the height is kept about 30 feet for ease of harvesting the fruit. The wood is not sturdy, so avocadoes are not planted in regions of strong winds. Since it cannot withstand freezing, its cultivation is limited to tropical areas. The leaves are long, maybe up to a foot in length.

The round or oval FRUIT can develop up to nine inches long and weigh two pounds. The tough skin may be green to black in color. The pulp or *mesocarp* is yellow and has a very delicate taste. It is rich in vitamins, has a higher percentage of protein than most fruits, and has from 5% to 30% fat. It is classified as a one-seeded BERRY. The fruit ripens after it is picked for market. The fruit is injured easily so it is gathered with shears or sharp hooks, with open canvas bags attached underneath. H. J. C.

Avocado

Avocets are shore birds

Avocet (AV-uh-set) The avocet is one of a group of birds that live along the shore of lakes, ponds, and rivers. Avocets are found in warm and temperate climates of both the eastern and western hemispheres. They have webbed feet, long legs, and a slender bill that curves upward toward the end. They wade, swim, dive, fly, and have loud, noisy, yelping voices.

The American avocet is partially tan and has distinctive black and white marks. It is found from southwestern Canada to Mexico and Guatemala. Plants, small water animals, and insects—including some that are harmful to man—make up the diet of this bird. The male and female take turns sitting on and protecting the eggs of their offspring.

The avocet is related to SANDPIPERS, plovers, stilts, and snipes. The scientific name for the American avocet is *Recurvirostra Americana.*

J. D. B.

Avogadro's Law see Gas

Avoirdupois system see Measurement, Weight

Axillary see Bud

Axle see Machines, simple

Axon see Nerve cell

Azalea (ah-ZAY-lee-yuh) Azalea is a shrub covered with beautiful, sweet smelling flowers. There are azaleas of almost every color except blue. Pink

Az

azalea bushes look
in a garden.

In May the Royal
pale pink flowers which
inches in diameter Th
flowered *flame* azalea g
open woods, but most az
to seven feet tall As wit
color of the flame azale
it has shade.

Azaleas are related to th
Some may be evergreen bu
ous. This ornamental shru
from a dwarf variety, one fo
that grow twenty feet tall
acid soil with an average *pH*
are attacked by a flower bligh
areas of the country Between
ods, this parasite lies dormant
hard coverings.

Azoic Era (uh-ZOH-ick)
is the name sometimes gi
earliest period in the earth's
is used to describe the tim
several billion years during
earth was formed and before
or animal life is known to hav

The Azoic Era is the first an
era in the geologic calendar which
age and the order of the appea
rocks, mountains, plants, and anim
some geologic calendars, *cosmic er*
term used to designate this time o
formation. Other tables omit the Az
and begin with the ARCHEOZOIC ERA
is assumed some kind of life already e
Pre-Cambrian is also used to
whole time span

MARY CURIE
• 1867–1934
Discovered radium and polonium

ENRICO FERMI
• 1901–1954
Produced first atomic pile and first controlled nuclear chain reaction

THOMAS ALVA EDISON
1847–1931 •
Invented light bulb, phonograph and mimeograph

NICOLAUS COPERNICUS
• 1473–1543
First astronomer to say that Earth goes around the sun

LUTHER BURBANK
• 1849–1926
Invented new varieties of plants

EDWARD JENNER
1749–1823 •
Discovered smallpox vaccine

CHARLES DARWIN
1809–1882 •
Conceived the Theory of Evolution through Natural Selection

WILLIAM HARVEY
• 1578–1657
Discovered the circulation of the blood

GEORGE WASHINGTON CARVER
1864–1943 •
Experimented with practical botany

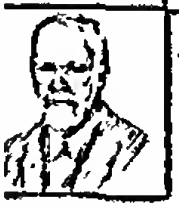
SAMUEL F B MORSE
• 1791–1872
Invented telegraph and Morse code

LOUIS PASTEUR
• 1822–1895
Invented pasteurization

BENJAMIN FRANKLIN
• 1706–1790
Invented lightning rod

GALILEO GALILEI
1564–1642
Discovered law of pendulum motion

CAROLUS LINNAEUS
1707–1778
Classified the plant and animal kingdoms



SIGMUND FREUD
1856–1939
Started psychoanalysis

GREGOR JOHANN MENDEL
1822–1884
Discovered principles of heredity

BARON ERNEST RUTHERFORD
1871–1937
Contributed to knowledge of radioactivity and atomic structure

GUGLIELMO MARCONI
1874–1937
Invented the wireless telegraph

LOUIS AGASSIZ
1807–1873
Investigated glacial motion and marine life

MICHAEL FARADAY
1791–1867
Discovered electromagnetic induction

SIR ISAAC NEWTON
1642–1727
Discovered laws of light gravity, motion and color

ALBERT EINSTEIN
1879–1955
Conceived the Theory of Relativity

WILHELM KONRAD ROENTGEN
1845–1923
Discovered X-rays